An Empirical Investigation into Stock-Flow Norms

Thesis

An Empirical Investigation into Stock-Flow Norms

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Abstract

The effect of a stock in a flow system is to absorb shocks to the flow as can be seen in many applications, from capacitors to flood plains. The ratio of the stock to its related flow may form a stationary time series, in which case its stable value is considered to be a *norm*. Such norms provide stable reference points in economic dynamics and have been associated with the New Cambridge school and the stock-flow consistent (SFC) modelling approach.

Using national accounts data for the US from 1960 to 2016, some common stock-flow ratios are investigated for stationarity, focussing in particular on those relating net financial assets to income for the sectors of an open economy. If sectoral balances are roughly stable, the wealth-income ratio will be stationary. It is found that, due to increased volatility over recent decades, stationarity is quite rare.

The norms figure in a dynamic process in which the fiscal stance and trade performance ratio, here termed the flow ratios, act through a multiplier to drive national income which is stabilised by the stock-flow norms. The process leads to convergence to the dominant flow ratio under the action of partial adjustment processes; which flow ratio is dominant depends on characteristics of the particular economy. Simulation is used to study the path of convergence and flow ratio dominance. The simulations are found to exhibit complex systems behaviour under certain circumstances.

A three sector SFC model is populated with the US data and estimated using a Johansen cointegrating VECM; interpreted as partial adjustment processes, the cointegrating relations for each sector yield estimates of the partial adjustment parameters and the stock-flow norms. This econometric approach emulates the Hendry *data-first* methodology whereby a pure data model captures the DGP in which postulated theory models are capable of interpretation.

Contents

List of Figures

List of Tables

List of Variables

All of the variables used in this thesis which have a time series representation are listed in the two data tables in chapter 3, namely table 3.2.8 for 'atomic' data, i.e. those consisting of a single time series, and table 3.2.4 for composite data, i.e. those combining two or more time series. The appropriate line in these tables is referenced from every table and plot in the document that uses time series data.

However, some equations in the exposition use symbols that may not have an associated time series representation and they are collected here.

Variable	**Description**
National Income Accounts	
C	Consumption
C_0	Fixed (not income dependent) element of Consumption
C_1	Average propensity to Consume
S	Saving
T	Taxes
T_T	Total taxes plus net transfers
Y	National Income
ΔY	Change in National Income
I	Investment
G	Government Expenditure
ΔG	Change in Government Expenditure
X	Exports
ΔX	Change in Exports
M	Imports

List of Variables

Variable	**Description**
ΔM	Change in Imports
θ	Average tax rate
θ_{T_x}	Ratio of total tax receipts to national income
θ_{T_t}	Ratio of total tax receipts plus net transfers to national income
μ	Average propensity to import
Flow Ratios	
Y_{GT}	Level of Income for public sector balance, i.e. where $Y = G/\theta$
Y_{XM}	Level of Income for foreign sector balance, i.e. where $Y = X/\mu$
Y_{CFTR}	Level of Income for private sector balance, i.e. where $Y = (G + X)/(\theta + \mu)$
Phillips' Integral Control Process	
px_t	private expenditure at time t
yd_t	disposable income at time t
fa_t	stock of financial assets at time t
ϵ_t	white noise error term
g	growth rate
k_1	coefficient of 'proportional' element of process
k_2	coefficient of 'integral' element of process
$t_1, t_2, ...$	discrete time points
Generic Partial Adjustment Processes	
S_t	Generic term for a stock at time t
ΔS_t	Change in a generic stock at time t
${S_t}^*$	Target level for a generic stock at time t
F_t	Generic term for a flow at time t
ΔF_t	Change in a generic flow at time t
${F_t}^*$	Target level for a generic flow at time t
α	Generic term for a stock-flow norm
ϕ	Speed of adjustment factor

List of Variables

Variable	**Description**
Private Sector Partial Adjustment Process	
PX_t	Private Expenditure at time t
YD_t	Disposable Income at time t
FA_t	Private sector Financial Assets at time t
α	Private Sector wealth-income norm
ϕ	Speed of adjustment factor
Public Sector Partial Adjustment Process	
G_t	Public Expenditure at time t
GD_t	Government Debt at time t
γ	Public Sector debt-GDP norm
ψ	Speed of adjustment factor
Foreign Sector Partial Adjustment Process	
PX_t	Private Expenditure at time t
FR_t	Foreign Reserves at time t
η	Private Sector wealth-income norm
ξ	Speed of adjustment factor
Inventory-Sales Ratio	
Y	National Income
S	Final Sales
Inv	Inventory
ΔInv	Change in Inventory
σ	Inventory-Sales ratio
σ^t	Target Inventory-Sales ratio
Capital-Output Ratio	
I_t	Aggregate Investment at time t
Q_t	Aggregate Output at time t
$Q^*{}_t$	Full capacity output at time t
K_t	Capital Stock at time t
$K^*{}_t$	Target Capital Stock at time t

List of Variables

Variable	Description
ν	Actual Capital-Output ratio
ν^*	Target Capital-Output ratio
β	Speed of adjustment factor
u	Rate of Utilization
Time Series	
x_t, y_t, z_t	generic symbols for time series
$\beta_0, \beta_1, \beta_2, ...$	generic symbols for coefficients of time series
μ	mean of time series
σ	std deviation of time series
ϵ_t	white noise error term
VECM	
$\boldsymbol{y_t}$	a $K \times 1$ vector for $t = 1 \ldots T$ where K is the number of elements of the vector $\boldsymbol{y_t}$
Π_i, Γ_i	$K \times K$ coefficient matrices of the lagged endogenous variables, where $i = 1 \ldots p$ where p is the number of lags.
$\boldsymbol{\mu}$	a $K \times 1$ vector of constants
$\boldsymbol{D_t}$	a vector of non-stochastic terms such as seasonal dummies or a deterministic trend
$\boldsymbol{\epsilon_t}$	a vector of independent and identically distributed 'white-noise' error terms with mean zero and time invariant positive definite covariance matrix $\mathbf{\Sigma} = E(\boldsymbol{\epsilon_t \epsilon_t'})$, meaning that $\boldsymbol{\epsilon_t} \sim \mathcal{N}(0, \mathbf{\Sigma})$
$\boldsymbol{\alpha, \beta}$	$K \times r$ matrices such that $\boldsymbol{\alpha\beta' = \Pi}$ where Π is the coefficient of the error correction term

Chapter 1

Introduction

The Global Financial Crisis and the ensuing protracted recovery have challenged many of the assumptions of mainstream macroeconomics[1] and the accepted approaches to macroeconomic modelling. The New Consensus in Macroeconomics (Woodford 2003, Goodfriend & King 1997), a synthesis of the “New Keynesian” model with the “New Classical” approach and ‘Real Business Cycle’ theory, was less than a decade old when the crisis struck and has come in for much criticism for not predicting it (Bernanke 2010, Krugman 2009, Solow 2010). Even the Queen was motivated to ask “why did no one see it coming?”. But prediction is difficult, especially about the future, as Niels Bohr is reputed to have said. Theories and models in the physical sciences have been able to provide precise forecasts in many areas (e.g. planetary motion) but not all

[1] This term is often used with variable meanings. Backhouse (2016) traces the use of the term from the 1960s (possibly when other streams started to emerge) via its treatment in Paul Samuelson’s textbooks. Snowdon & Vane (2005) charts the changing nature of the economic thought that is referred to by the term from the neo-classical synthesis in the 1950s to the emergence of the New Synthesis in the 2000s which brings together parts of the New Classical and New Keynesian traditions. At the time of the crisis, this was ’the mainstream’ (Woodford 2009).

(e.g. meteorology). Prediction in economics has always had more in common with meteorology than planetary motion for reasons that will be discussed below.

To identify who *did* see it coming, Bezemer (2009) conducted a search of the pre-crisis literature; he points out that predicting bubbles and crashes has become something of a growth industry and, like a stopped clock, these predictions are bound to be right eventually. "Random guesses are supported by all sorts of reasoning (if any at all), and will have little theory in common. Conversely, for a set of correct predictions to attain ex-post credibility, it is required that they are supported by a common theoretical framework" (p.7). To separate out the professional doomsayers and lucky guessers he applied four selection criteria: firstly, only analysts were included who provide some account of how they arrived at their conclusions; secondly, they went beyond predicting a real estate crisis, and made the link to implications for the real-sector, and were able to give an analytical account of those links; thirdly, the actual prediction must have been made by the analyst and available in the public domain, rather than being asserted by others, and finally, the prediction had to have some timing attached to it. Based on these criteria, he identified twelve analysts and their assessments (op.cit.p.9); each of the twelve in different ways conveys concerns about wealth, debt, and credit flows, which Bezemer asserts is equivalent to saying that the authors take an 'accounting' or 'flow-of-funds' view of the economy. This is most explicit with Keen (2006), Hudson (2006), and especially Godley (1999c) and Godley *et al.* (2007), who each actually present explicit accounting models of the economy. Key features of such models include (a) the circular flow of goods and money, (b) a separate representation of stocks (inventories, wealth and debt) and flows (goods, services and funds), (c) explicit modelling of the financial sector as distinct from the real economy, so allowing for independent growth and contraction effects from finance on the economy, (d) non-optimising behaviour by economic agents in an environment of uncertainty, and (e) accounting identities (not the equilibrium concept) as determinants of model outcomes in response to shocks in the environment or in policy (Bezemer 2009, p.12). It is one of these explicit accounting models of the economy, specifically that which informed the pre-crisis assessments of Wynne Godley, his colleagues and collaborators, that is the subject of this research; nothing further will be said of the other eleven, and very little of the 'New Macroeconomic Consensus'.

Godley was an *applied economist*, working within the post-Keynesian tradition in macroeconomics (Eichner & Kregel 2001, Arestis 1996, Harcourt 2006, Lavoie 2014); his major contributions were in the area of macroeconomic modelling, in particular, the Stock-Flow Consistent (SFC) modelling approach of which he was a co-founder and which qualified as one of Bezemer's twelve analysis methods. Godley would not claim to have *predicted* the crisis, but rather to have warned repeatedly about the large and unsustainable imbalances building up in the US economy in the pre-crisis period, as evidenced by studies published in the series Strategic Analysis from the Levy Economics Institute of Bard College from 1999 - 2008 (Levy Institute of Bard College 1999).

Chiang (1984) identifies three stages of development of macroeconomic modelling; the first models were *static* models, which dealt only with the question of what the equilibrium position would be, given certain combinations of values of the variables of a model; the *attainability* of the equilibrium was not called into question. The next stage was *comparative static* modelling, in which the question changed to how the equilibrium position will shift in response to a change in an exogenous variable or parameter; again the *existence* of equilibrium was not in question. The final stage is *dynamic modelling*; it is only here that the attainability of the equilibrium is directly addressed. The question now becomes "if the economy is 'out of equilibrium' for whatever reason, will the forces in the economy direct the system towards an equilibrium position? and what is the nature of the path it will follow - steady, fluctuating or oscillatory?" This question identifies a fundamental schism in current macroeconomic thought, between those who believe that the economy is self-equilibrating, that markets will clear as price adjustments bring supply and demand into balance, and those who, following Keynes, believe that the economy can settle into an 'out-of-equilibrium' position for an extended time and that there are not necessarily any 'endogenous' forces tending to restore equilibrium. The example that occupied Keynes was unemployment in the 1930s, and *The General Theory* (Keynes 1936) was an explanation of how an economy can get into a protracted disequilibrium and what could be done about it. Disequilibrium economics recognizes that states of equilibrium do occur under certain circumstances, but doesn't consider that it is the natural state of affairs.

Chiang (1984) goes on to draw attention to two specific limitations in dynamic modelling. Firstly, to make the analysis manageable, dynamic models are often formulated in terms of linear equations. While simplicity is thereby gained, the cost may be in the sacrifice of some realism. This particular limitation may have lost some of its force more recently, since it is now commonplace for models to be solved computationally rather than analytically which means that they are fully capable of exhibiting non-linear dynamics. Godley's SFC models are firmly set in this dynamic category. The second limitation is the assumption of constant parameters in the equations of the models. This serves to 'freeze' the economic environment of the problem under investigation, it means that the endogenous adjustment of the model is being studied in a sort of economic vacuum, such that no exogenous factors are allowed to intrude. Of course, an assumpton of stable model parameters may be appropriate in many situations, but it is an assumption nevertheless.

These last two caveats point towards a further evolution of dynamic modelling which has been termed *Complexity Economics*; this is an adaptation of Complexity Science to the study of economic systems. Complexity science is an interdisciplinary field whose definition is still very much open to debate, although the term 'complex system' does have some generally agreed properties:

1. Multiplicity of many parts, out of whose interaction emerges behaviour not present in the parts alone
2. Coupling to an environment with which information, energy, or other types of resources are exchanged
3. Presence of both order and randomness in (spatial) structure or (temporal) behaviour
4. Absence of a central control element, either internal or external
5. Robustness of structure and/or behaviour against significant perturbation
6. Presence of memory and feedback; enabling adaptability according to its history or feedback

Examples include ant colonies, insect swarms, the climate, and the economy.

The last feature, *adaptability*, is central, so much so that complex systems are often called *complex adaptive systems* to emphasize this key characteristic; it is the reason why parameter values are not fixed in realistic models. Examples of the application of complexity science to economics can be found in the work of Beinhocker (2006), Moore (2014), Arthur (2014), Bookstaber (2017) among others. Such systems are characterized by non-linear disequilibrium dynamics evolving in historical time, heterogeneous agents, emergent properties and evolutionary development.

Returning to the problems of prediction broached in the introductory paragraphs, comparison of the predictions of planetary motion with those of meteorology illustrates the different forecasting horizons possible between deterministic systems and complex systems — even with major advances in non-linear dynamics and computation, forecasts in meterology are still only reliable for a matter of days ahead. But there is a second dimension affecting economic modelling besides complexity - economies are *social* systems; much of the adaptability that gives rise to the complexity of the economy is to be found in the enormously diverse behaviour of the individuals and institutions that form its working parts. If the forecasting ability of a complex *physical* system like meteorology is so modest, then we need to be quite humble about our ability to make precise predictions in a complex *social* system like the economy; rather than prediction, a more realistic aspiration for economics might be *understanding*, that is, theories and models should provide general insight into the workings of an economy to enable reasoned and evidence-based judgements to be made about policy alternatives and about its stability and sustainability.

Fathoming human behaviour, both at the individual and the group level is still beyond the state of the art, so economists have had to resort to simplistic models like the rational, optimising behaviour of *homo economicus*. Behavioural economics is a relatively new research area that introduces results from psychology and neuroscience concerning human behaviour and particularly group behaviour to economic questions (Kahneman & Tversky 1979, Shiller 2000, Thaler & Sunstein 2008, DeGrauwe 2012); the hope is that the greater realism of behavioural economics will gradually displace the assumptions of neoclassical microeconomics. Soros (1987) coined the term *reflexivity* to capture the concept of the cycle of self-referential feedback between the beliefs and expectations of economic agents which determine their actions and, in the process, alter outcomes for the economy overall; and observations of the new economic context lead to ideas that change expectations and behaviour, which in turn change the economy, and so on, *ad infinitum*.

This issue of the microeconomic basis for modelling leads on to the question of the 'microfoundations' of macroeconomics, which identifies a second 'schism' in macroeconomics. Current mainstream thinking insists that macro-models must be fully 'micro-founded', that is, the behaviour in the macro-model should be traceable from the microeconomic theory of individual agents. Bearing in mind what has just been said about complex systems, many economists, including Godley, consider this to be a fallacy, and this study is to be counted among those.

This leads to one of the questions that this thesis addresses, that is, the extent to which meaningful results can be derived about the behaviour of an economy purely in terms of variables visible only at the aggregate macro-level. This thesis involves the construction of a highly aggregated three sector model of the US economy solely from time series data at the macro level. It works on a *black box* principle, borrowed from systems theory, in which the behaviour at a certain level of aggregation is described purely in terms of quantities that are 'visible' at that level, all of the lower-level complexity is 'hidden' inside. Naturally, there is less that can be said at the high level since there is less information available, but the analysis can progress to lower levels step-by step as the black box is 'opened up'; so for example, the three sector model could be disaggregated by splitting the private sector into sub-sectors, results obtained at the high level are still binding at lower levels. This approach is the antithesis of the microfoundations approach and is one of the contributions of this research.

The previous paragraphs have presented some general characteristics of macro-models which the SFC models share — fully dynamic disequilibrium models as outlined by Chiang (1984), capable of representing complex adaptive systems and incorporating an accounting/flow-of-funds based method conforming to Bezemer's criteria on page 3, but there are some additional points in those criteria that deserve further description: 'balance sheet economics', 'stock-flow consistency' and 'real-financial integration'.

Balance sheet economics could be seen as a move away from the 'pure flow' models of the economy towards a recognition of the importance of stocks in individual and collective decision making. Stocks are accumulations of flows from past periods and as such capture the history, the path which has been followed to get to the present state, and they represent the present state itself. Balance sheets set up cash-flow commitments, they capture the current financial position of individual agents and constrain their future behaviour. When individual balance sheets are consolidated, the aggregate balance sheet is a powerful indicator of the stability of the economy overall. These ideas are most closely associated with the work of Hyman Minsky and led to his *Financial Instability Hypothesis* (Minsky 1986). The aggregate balance sheet is a core element in all SFC models. It is a manifestation of the more general principle of *stock-flow consistency* which ensures that all surpluses and deficits in transaction flows in a model are associated with a corresponding stock; each period's flows update end-of-period stocks and updated stocks influence next period's flows, and so on, setting up a natural dynamic in the model. Referring back to Bezemer's list of model requirements (page 3), he postulates that accounting identities (which express stock-flow and flow-flow consistency) are the real determinants of model outcomes in response to shocks to the economy, not the equilibrium concept[2].

By the term 'real-financial integration', is meant the impact of the financial system on the 'real' economy, and vice versa (this was point (c) in Bezemer's criteria for sound models, pg. 3). It was James Tobin, the other co-founder of SFC models, who, in his prospectus for a new standard macromodel (to be discussed in section 2.1.3) insisted that realistic models should ensure full tracking of stocks, contain several assets and rates of return together with modelling of financial and monetary policy operations capturing the way they alter the wealth and portfolio positions of economic agents. The financial side of the economy, through its effect on the asset portfolios of individuals, impacts

[2]Stock-flow consistency simply requires that net inflow equals change in stocks; it is a *consistency* condition (discussed further in §2.3.1.3. The concept of a stock-flow norm arises when the stock-flow axiom is added (discussed further in §2.1.3; it is a *stability* condition. The two taken together imply a stable ratio between the stock and the flow.

the ‘real’ economy through their consequent saving and expenditure decisions. Other modelling approaches that only represent one side or the other, or model the two separately, fail to capture their true interaction, which is why they “didn’t see it coming”.

The foregoing has built up a picture of the approach to macromodelling that SFC models represent; a further element, that is rather specific to this thesis is the approach to econometric modelling. SFC models are formulated as a set of structural and behavioural equations in a way that will be made explicit in later chapters. These models may incorporate complex systems elements to a greater or lesser extent, but there then arises a choice of methods of solution of the models; computational and analytical solutions were mentioned above and computational methods will be used in this work, but one of its principal objectives is to be able to construct *fully empirical* SFC models and to deploy econometric methods of solution. The term ‘fully empirical SFC model’ will be applied to SFC models constructed in the following way: rather than formulating a set of behavioural equations to capture the relationships between the variables of the model, actual time series from the US national income accounts will be used to represent the variables, and the relationships between them derived econometrically. The econometric approach to be used is the Johansen cointegrating VAR methodology (Johansen 1995) which allows long-term empirical relationships between system variables to be inferred from the cointegrating relations of the VAR. This is an instance of a method that has acquired the name the ‘data first’ approach (as opposed to ‘theory first’); it is founded upon the ideas of the Hendry methodology (Hendry 1995), also known as the ‘LSE methodology’. This will be elaborated in chapter 3, but the idea in brief is that the economy is an extremely complex multi-dimensional system that can only be observed through the medium of the data that it generates. The *Data Generating Process* (DGP) can be thought of as a measurement system fully embedded within every aspect of the economy. Large parts of the DGP may be unobservable, the data that is available may be a subset of it, the challenge to the researcher is to construct a statistical model of the available data that *encompasses* the DGP. If the constructed model is a faithful representation of the underlying data generating process, then competing theory models will be interpretable within it. This is in contrast to the 'theory first' approach in which models are constructed on the basis of the behavioural assumptions of an economic theory and then a dataset is generated to try to confirm or refute the theory model. Of course the data-first approach is open to charges of positivism, especially if it is inferred from this description of it that everything is assumed to be measurable and only measurable quantities are to be considered. Additional data may be added to give a richer empirical model, if that helps to make more precise inferences.

The way the data-first principles will be applied here is by construction of a three sector model of the US economy in the form of an SFC model which will be fully populated with data from the US national income accounts. A cointegrating VAR estimation of the populated SFC model is the statistical model in which attempts will be made to interpret Godley's theory of the dynamics of the economy; this dynamic theory will be introduced now.

The methodology that Godley employed consisted of combining SFC models with the use of a particular style of *ratio analysis*, which incorporate a view of how monetary economies[3], treated as *whole systems*, function. Central to this view was the idea that one group of ratios, the *flow ratios*, capture the extent of 'injections' into or 'leakages' from the economy, and this in turn determines national income through a *multiplier* process. These changes in national income are themselves stabilised by a second group of ratios, the *stock-flow norms*. This set of processes, the flow ratios driving the system through the action of the multiplier and stabilised by the stock-flow norms, together define a dynamic system which is to be found in most of Godley's published models. The most notable example is his 1999 paper *Seven Unsustainable Processes* (Godley 1999c) in which, by analysis of exactly that dynamic process, he identified unsustainable imbalances in the US economy in the run up to the dotcom bubble, in complete defiance of the received wisdom at the time that considered the US economy to be in a period of 'Great Moderation'.

The flow ratios consist of the *fiscal stance* which measures injections and leakages from fiscal policy into the private sector; and the *trade ratio* which measures injections and leakages from foreign trade performance. These injections and leakages work through into economic activity through the action of a multiplier, moderated by the action of the second group of ratios, the stock-flow norms. These are ratios of particular stocks from the aggregate balance sheet to their associated flows, such that their ratio exhibits some degree of stability over time. It is the time stability that is the criterion for a ratio to qualify as a

[3]This is a term often used by Godley, e.g. Godley (1996 1997) (it also appears frequently in the literature on Graziani's monetary circuit, e.g. various papers in Graziani *et al.* (2003)); he sometimes just referred to 'a money economy' (Godley & Cripps 1983, p.47) but also 'monetary production economy' Godley & Lavoie (2007c), Lavoie & Godley (2003), Godley (2003b). It refers to the post-Keynesian notion of endogenous money in which there is a need for finance in advance of production and sales taking place. Such finance takes the form of bank loans and therefore there is a need for banks with the power to create credit money. This is in contrast to a Wicksellian loanable funds model in which banks are mere intermediaries, accepting savings and allocating them to borrowers.

norm. The stock will absorb fluctuations in the flows and cause a return to the 'normal' level in the event of a displacement. Godley & Cripps (1983) motivate this with the analogy of a river system flowing into a lake. If the inflow suddenly increases, the lake level will rise, but this will cause the outflow to increase. Eventually, provided the shock to the inflow was temporary, the level will return to normal. The stock of water has absorbed the surge in the inflow, and the topology of the river system determines the level that the lake will return to. The most significant of the stock-flow ratios is the private sector wealth-income norm, which hypothesises that the private sector has some target level of financial wealth in relation to disposable income and will adjust saving and expenditure decisions to achieve this target. If there is a sudden increase in disposable income, it will be temporarily 'absorbed' as higher levels of private wealth until expenditure adapts to the new level of income and wealth settles to a new level consistent with the norm. Various alternative explanations for the working of the wealth-income norm will be explored in later chapters.

This finally brings together all of the components of the economic model to be studied in later chapters. One could say that conventional practice in macromodeling, involves formulating a set of fixed-parameter equations to capture functional relationships between the variables of interest based on behavioural assumptions from economic theory, equations that are then solved analytically, numerically or by means of econometric estimation. By contrast, the approach to model building in this thesis consists of identifying the sectors and transactions of an SFC model, and choosing appropriate variables to represent them, which are captured empirically by time series data from the relevant national income accounts, possibly supplemented with data from other sources. These time series are subjected to preliminary analysis to determine stable ratios between stocks and flows and possibly between flows and other flows. Based on the outcome, the model is transformed into a VAR model which forms the the most general model of the data in Hendry's method, to be subjected to the usual barrage of tests to check for stationarity, breakpoints, linear, polynomial, exponential trends, cointegration and general-to-specific refinement to eliminate variables of low significance. The result is a fully empirical SFC model, capable of capturing complex behaviour, whose dynamics are regulated by stable ratios in place of equilibrium assumptions, and which is general enough to be able to test theoretical hypotheses; the specific hypothesis under test in this case is to be Godley's dynamic process, which asserts that the flow ratios drive the system through the action of the multiplier, stabilised by the stock-flow norms.

One clear consequence of Godley's view of the workings of an economy is a greater emphasis on fiscal policy as a determinant of economic outcomes. The 'New Consensus' model, which is the currently accepted standard for policy makers, accords no role to fiscal policy, monetary policy can do it all. According to this view, fiscal expansion merely leads to higher inflation and higher interest rates and has no effect on economic outcomes (Fontana & Passarella 2016, p.5). While this view does not command unanimous acceptance, even amongst mainstream economists (Kirsanova *et al.* 2009) and certainly not amongst post-Keynesians (Sawyer 2011, Arestis & Sawyer 2011b, Lavoie 2006), it remains a default assumption in many current macroeconomic policy prescriptions - the 'Washington consensus', the Eurozone's stability and growth pact, the Labour Party's proposed fiscal rule, for example, and has been used as a justification for post-crisis austerity policies (DeGrauwe & Ji 2013). If Godley's dynamic process of flow ratios, the multiplier and the stock-flow norms is correct, then it implies that this aspect of policy may have been misguided.

1.1 The Research Prospectus

This chapter so far has explained the background and context to this approach to macromodelling and the specific dynamic process which is under test. These general points will now be translated into a specific research programme.

1.1.1 The Research Question

The central question that this research seeks to answer is "to what extent does the dynamic process formed of the flow ratios, the multiplier and the stock-flow norms find empirical support in US national income data in the period 1960 - 2016?"; this could be termed *Godley's hypothesis*. A secondary question arises out of the methodological approach to answering the first, and addresses the extent to which meaningful results can be derived about the behaviour of an economy purely in terms of variables available only at the aggregate macro-level; is it possible to formulate useful relationships amongst the variables available at any level of model aggregation? A third relates to the role of the empirical model in interpreting and testing an economic hypothesis, the above description of the methodology suggests that the cointegrating VAR will be used as a most general model of the data in the terms of the Hendry methodology, and Godley's hypothesis should be interpretable within it; conclusions of a qualitative nature should be possible following this experience.

1.1.2 The Objectives of this Research

The key objectives of this research project include:

1. To use historical data from the US economy to study the behaviour and to assess the stability of the flow ratios and the stock-flow ratios with the objective of making a judgement about Godley's assumption of the existence of stable stock-flow norms. Contributing to this objective will be a review of the literature on alternative explanations of stable stock-flow relationships.

2. To use an aggregated three sector SFC model of the US economy to formulate macro-relationships amongst the high level variables of the model and, by populating the model with historical data from the US national income accounts, to formulate these relationships in empirical terms.

3. To transform the populated SFC model into a cointegration VAR with the purpose of extracting the long-run cointegrating relations to test the hypothesis of the effect of the flow ratio - multiplier - stock-flow norm dynamic process on the US economy. This action will also explore the applicability of the Hendry methodology.

4. To study the interaction of national income and the flow ratios and their convergence under the stock-flow norms. This will be accomplished principally by means of computational simulations, but also with some econometric analysis of time series. The objective is to classify the different convergence patterns and compare with patterns from real economies based on European data.

1.1.3 The Contributions of this Research

This research will contribute to the literature on stock-flow and empirical modelling, firstly by providing a new way of doing fully empirical SFC models. The leading approach to empirical SFC model building is that of the Levy Institute models (Zezza 2009) which are an evolution of the model developed in Godley (1999c). My approach differs from those in the respect that it proposes no *a priori* relationships between variables, but rather uses a general to specific approach and VAR estimation to reveal relationships contained in the data. Secondly, it contributes to the literature on stock-flow norms; it performs empirical investigations of the behaviour of several stock-flow ratios by means of historical data; it performs comparative studies of alternative stock-flow ratios to assess their stability; it compares time series stationarity vs cointegration as a criterion for norms; it discusses reasons for shifts in stock-flow norms; and it identifies alternative explanations for the stability of ratios of stocks and flows. Godley & Cripps (1983) treats stock-flow stability as an *axiom*, a fact to be accepted but not explained. However, there are other threads in the literature which treat this phenomenon differently — Phillips (1954) identifies proportional-integral control mechanisms that result in the same behaviour; Modigliani & Brumberg (1954), Modigliani (1966), Modigliani *et al.* (1980) define the *Life Cycle Hypothesis* (LCH) which defines relationships between wealth and income under growth and no-growth assumptions. Finally, it contributes to the literature on economic dynamics through an investigation of the flow ratio - multiplier - stock-flow norm dynamic process through simulation as well as econometric estimation. The simulations define a novel classification scheme for surplus and deficit economies based on the relationship between the fiscal stance, the trade ratio and national income and illustrates them with examples from several European economies. The econometric study assesses the empirical evidence for the existence of the dynamic process.

In addition, affirming the action of the dynamic process calls into question the mainstream assumption that fiscal policy is ineffective in regulating the level of economic activity, and calls for a reassessment of the role of fiscal policy in overall stabilization policies.

1.2 The Structure of the Thesis

The next chapter surveys the relevant literature, starting with the general macroeconomic background, then looking at ratio analysis and its place in economic dynamics, leading on to a review of the SFC method itself, its origins and current state. Finally, the literature relevant to the chosen econometric approach, the Hendry methodology and the ‘data first’ concept.

Chapter 3 first introduces the methodology behind the research, starting with the underlying assumptions; this section elaborates on the ideas of complex adaptive systems briefly introduced in this section. The methodological approach consists of three complementary activities — descriptive analysis, logical analysis and econometric estimation — and the way of proceeding with these three activities is defined there. The second part of that chapter deals with the data sources, giving a comprehensive and detailed tabular presentation of every time series used in the later chapters. It also gives an overview of the software that is used to download, process and present the computations on the data.

Chapter 4 deals with *ratio analysis*, firstly the flow ratios and then the stock-flow ratios. The analysis proceeds with a combination of descriptive analysis, mainly by means of time plots of historical data, then applying stationarity tests to assess the stability of the stock-flow ratios. The main task of the chapter is to choose among alternative candidates for the financial assets-income ratio for each of the sectors of the three sector model to be developed in later chapters. The final part of the chapter takes a look ahead at stock-flow ratios for non-financial assets, the inventory-sales ratio and the capital-output ratio, which would be part of a richer model with a disaggregated private sector.

Chapter 5 is concerned with the convergence process of the Godley dynamic described above. It puts the flow ratios and the multiplier together with the stock-flow ratios to study the convergence process through logical simulations as well as econometric tests, for example Granger causality. These lead to a 'classification' for economies based on their convergence patterns; these are compared with historical time series from several European countries.

In chapter 6 a three sector SFC model of the US economy is constructed and populated with data from its national income accounts. Cointegrating VAR models of the three sectors are estimated in order to be able to interpret the flow ratio - multiplier - stock-flow norm dynamic process for each sector within the model. In this way, Godley's hypothesis that this process is a driver of the economy can be assessed.

Chapter 7 summarizes and draws together the conclusions and looks ahead at how the approach might be applied to more realistic, disaggregated models.

Chapter 2

Review of the Literature

The purpose of this chapter is to position Godley as an economist within the stream of economic thought that influenced his work and to place his approach to economic modelling within the rather turbulent developments in the discipline in the late twentieth century. But in addition, since there is a distinctive empirical element to this thesis, a section covering the origins of the relevant developments in econometrics is included. Section 2.1 positions Godley's modelling approach within its general macroeconomic background; section 2.2 identifies the relevant influences from ratio analysis and economic dynamics; section 2.3 surveys the growing literature on the SFC modelling methodology itself; section 2.4 assesses the relevant literature on the econometric approach and section 2.5 briefly summarizes what has been said in the preceding sections.

2.1 The Macroeconomic Background

Wynne Godley was a Keynesian economist aligned with the *post-Keynesian* view in macroeconomics (Eichner & Kregel 2001, Harcourt 2006, Arestis 1996, Lavoie 2014). His early economics education was at Oxford, under the influence of P.W.S. Andrews, and he served his 'apprenticeship' at H.M. Treasury from 1956 to 1970, engaged on short-term forecasting. This involved trying to predict the path of output, employment and inflation during the next 18 months and devising policy interventions to try to correct anything that might go wrong (Godley & Lavoie 2007c, p.xxxvi).

A Keynesian, but also a Kaldorian; Kaldor became a mentor while he was doing work for the Treasury and was instrumental in getting Godley appointed Director of the Department of Applied Economics at Cambridge in 1970. Godley later said that Kaldor "was touched by genius" (Godley & Lavoie 2007c, p.xxxvi). While the influence of Kaldor's work on growth and the business cycle (Kaldor 1956 1961 1985) was clearly important, it is perhaps his methodological influence that has most profoundly affected Godley's later work. Particularly in his later writings, Kaldor became increasingly concerned with methodological issues in economics (Kaldor 1972 1975) and how it had led economic theory into a "cul-de-sac" (op.cit p.347). He was vocal in his demands for an 'empirical' approach to economics, and increasingly critical of the 'axiomatic' basis of neoclassical economics,

> ...unlike any scientific theory, where the basic assumptions are chosen on the basis of direct observation of the phenomena the behaviour of which forms the subject-matter of the theory, the basic assumptions of economic theory are either of a kind that are

> unverifiable – such as that producers m̀aximise' their profits, or consumers m̀aximise' their utility – or of a kind which are directly contradicted by observation – for example, perfect competition, perfect divisibility, linear-homogeneous and continuously differentiable production functions, wholly impersonal market relations, exclusive role of prices in information flows and perfect knowledge of all relevant prices by all agents and perfect foresight (Kaldor 1972, p.1238).

It is to Kaldor that we attribute the concept of 'stylised facts' (Kaldor 1957 1961) as part of an appeal for 'realism' in economic theory; looking at the original facts that he cited, these were empirical regularities that had been observed over a considerable period, he didn't claim that they were fixed or unchanging; most of them challenged the received wisdom of orthodox economic theory of the time, "None of these 'facts' can plausibly be 'explained' by the theoretical constructions of neo-classical theory" (Kaldor 1961, p.179). This was Kaldor's way of emulating the methods of science in theoretical economics; here were observations of the economy that were inconsistent with current theory and he was challenging economic theorists to produce credible explanations. Kaldor was extremely sceptical of the value of econometrics as a means to provide an empirical basis for economic theory, so stylised facts were a practical 'middle way' of keeping theory grounded, avoiding the vacuous self-referential contemplations that follow from the type of 'unverifiable' or downright false assumptions he draws attention to in the above citation, but without becoming immersed in a sea of statistical data as seemed to be the fate of econometricians[1].

[1] It is interesting to speculate on whether his views on econometrics might eventually have

It was an exactly similar stylised fact that would later lead Godley and colleagues at the Department of Applied Economics to propose the *New Cambridge hypothesis*, of which more below.

2.1.1 The Standard Model and the post-Keynesian Alternative

Kaldor's critique of the axiomatic-deductive methodology of mainstream economics was echoed in many of Godley's writings. It was quite routine for him to contrast the mainstream, neo-classical 'standard model' with his own in any introduction to his work. The following, perhaps the most recent, is taken from his book *Monetary Economics* co-authored with Marc Lavoie and is fully representative of his view of the mainstream,

> the neo-classical paradigm is based on the premise that economic activity is exclusively motivated by the aspirations of individual agents. It requires a neo-classical production function, which postulates that output is the result of combining labour with capital in such a way that, provided all markets clear, there will be no involuntary unemployment, while the national income is distributed optimally between wages and profits...firms' optimum prices, output and employment are all decided for them by the location of aggregate demand and supply schedules. And as production is instantaneous, while supply is brought into equivalence with demand through the market-clearing process, there is no systemic need for loans, credit money or banks. The concept of m̀oney'

changed, as Keynes' did; what would he make of current àdvances' in econometric practice in the age of b̀ig data'?

> is indispensable, yet money is an asset to which there is not, in general a counterpart liability and which often has no accounting relationship to other variables. Mainstream macroeconomic theory is a deductive system which needs no recourse to facts (though it may be calibrated with numbers) and lends itself to analytic solutions (Godley & Lavoie 2007c, p.1).

He might have been accused of creating a strawman, right up until the global financial crisis, when even many mainstream writers started to voice similar criticism (Buiter 2009, Blanchard *et al.* 2010, Krugman 2009) to name just a few. The Buiter critique is particularly devastating, attacking the same unrealistic assumptions and self-referential irrelevance as Kaldor 30 years earlier. The Blanchard article is a more honest *mea culpa*, while the Krugman one is more about points scoring in the perpetual contest between the 'saltwater' and 'freshwater' schools in the US[2].

The reason for quoting this passage at length is that it is important to see how Godley understood the standard model, and to let him state it in his own voice. Whether or not that is an accurate portrayal of how mainstream economists view the world is not important, and, no doubt, many of them would reject it, the point is that that is what Godley saw himself working against. Most of his publications commenced with a similar passage, followed by the presentation of a model based on alternative assumptions. The key points of his objections are,

1. The focus on individual behaviour: this embraces the whole subject of 'microfoundations of macroeconomics' which has generated fierce debate

[2]Krugman has since recanted, and considers that mainstream economics is doing just fine.

and a large literature, Janssen (2006) provides a useful survey. Whereas in the standard model macroeconomics is viewed as an aggregation of individual behaviours, the post-Keynesian alternative is rather one of 'disaggregation', starting from the consistency of the whole which fixes constraints within which individual behaviour evolves. Kriesler (1989, p.123), writing about the work of Michal Kalecki, identifies two hypothetical extremes: "the first as seeing macroeconomics as a pure aggregation from the micro, with no new information resulting from the aggregation that is not already in the micro theory. On the other hand, the second view can be characterised as regarding the micro as a pure disaggregation from the macro, with no new information about the functioning of the economy being generated by the procedure". Arthur (2014) considers that a proper understanding of a macroeconomy requires two simultaneous processes, the composition of individual behaviours emerging from the current economic context, including agents' expectations, macroeconomic conditions (interest rates, tax rates, employment levels etc); this composition is not just an aggregation, but involves complex interactions between heterogeneous groups of agents and institutions; the result of the composition is a new macroeconomic context that affects expectations, budgets, employment levels etc and the cycle repeats, in fact it is less an iterative cycle and more a continuous process. This is the *complex adaptive systems* view of an economy, introduced earlier (p.6) which will be developed further in chapter 3.

Keynes identified the need for a separate 'theory of output and employment *as a whole*' (Keynes 1936, p. 293, original emphasis). Godley often emphasised that he was interested in "how whole economic systems function" (Godley & Cripps 1983, p.41). King (2012) identifies two distinct but closely related issues in the microfoundations discussion - the *fallacy of composition* and *downward causation.* The fallacy of composition says that complex systems like macroeconomies act as whole systems — the properties of the whole could not be inferred from the properties of their parts. This is closely related to the concepts of *emergence* - where the whole possesses properties not present in the parts - and *irreducibility* which says that emergent properties cannot be explained even with a complete understanding of more basic phenomena, i.e. emergent properties are autonomous from the more basic phenomena that give rise to them. Downward causation just captures the idea that properties and behaviour of the whole influence the parts - "before there is any hope of undertaking meaningful micro analysis, *one must first determine the macro context within which that micro decision is made*" (Colander 1996, p.61; original emphasis)). This is just the second half of the cycle that Arthur (2014) refers to above.

2. The absence of institutions; this is a corollory of the methodological individualism discussed under the previous point. This view leaves little room for separate behaviour of firms, banks, governments as autonomous entities with their own objectives; it also has implications for the role of fiscal and monetary policy; current mainstream economic thinking holds that fiscal policy has no place in macroeconomic management, monetary policy can do it all; fiscal policy is relegated to maintaining balanced budgets. In the whole of Michael Woodford's *Convergence in*

Macroeconomics: Elements of the New Synthesis (Woodford 2009), fiscal policy is never mentioned.

> With the new consensus, as in the old one, expansionary fiscal policy leads to higher inflation rates and higher real interest rates in the long run, while it has no impact on real activity; more restrictive monetary policy leads to lower inflation rates in the long run, without any (long run) impact on real interest rates and economic activity (Lavoie 2006, p.167).

This belief has been used, among other things, to justify fiscal austerity in the post-crisis period; Godley's views on policy were the inverse of those of the mainstream, as will be discussed further below; if his version is correct, it would not only refute that belief, but also go quite a long way to explaining the lack-lustre recovery from the global financial crisis, despite the use of 'unconventional monetary policy' and a decade of zero and even negative interest rates in many of the world's developed economies. The inclusion of sectors into SFC models is a means of modelling the diverse behaviour of economic institutions.

3. The Neo-classical Production Function: Felipe & McCombie (2014) provides a historical account of the aggregate production function and addresses the question of why it still underpins so much of current mainstream economics despite so many objections. The most likely answer they find is that 'it works' providing a 'good fit' against macroeconomic data, despite this having been explained as a consequence of its simply being a restatement of an accounting identity (Shaikh 1974).

As well as these objections, Godley objects to the assumption of distribution according to marginal factor productivities[3]. He adhered to the theory that it is the price system that distributes the national income, with the consequence that inflation is a result of conflict over income shares between profits and wages (Rowthorn 1977).

4. Equilibrium Economics; it is an assumption of most mainstream thinking that aggregate demand and supply are brought into market clearing equilibrium through adjustments in prices, even if there may be lags in the adjustment process due to 'sticky prices'; and since that assumption has been extended to the labour market, there can be no involuntary unemployment. Godley used equilibrium concepts in his models (Godley & Lavoie 2007c) — a *stationary state* where stocks are not changing, and a *steady state* where stocks are growing at a uniform growth rate — but these were not states one expects to find in a real economy, but start and end states of an adjustment process that allowed him to study the dynamics in disequilibrium. Moreover, it was not price adjustments that drove these dynamics, but quantity adjustments (inventories and production volumes) in response to unrealized expectations and budget constraints.

5. The Absence of Historical Time; since the time of Joan Robinson's distinction between logical time and historical time (Skott 2005) the treatment of time has been an important issue for post-Keyesians in their quest for greater realism in models. There is a considerable post-Keynesian literature on the subject, Lavoie (2014, p.34) provides a survey. For Godley, the more realistic treatment of time is an important outcome

[3]For example, in the passage cited on page 24

of computational methods of solution.

6. The treatment of money; the role of money in macroeconomics is a subject in itself and has also been a point of departure between the mainstream and post-Keynesians, Lavoie (2014) gives an overview of the respective positions, Arestis & Sawyer (2006) assembles diverse post-Keynesian contributions. One of the planks of post-Keynesian thought has been 'endogenous money' (Moore 1988) even if this has led to internal debates between the 'horizontalists' and the 'structuralists' (Fontana 2004). 'Modern Monetary Theory' (Wray 1998) may be seen as an outgrowth of this work. Godley highlights the inadequate treatment of monetary economics in mainstream models repeatedly in his writing[4]. One of the key objectives of the SFC modelling approach is to integrate the monetary and the 'real' side of the economy so that their interactions can be understood.

7. The Emphasis on Deductive Reasoning; Godley is ever-critical of the methodological approach of reasoning from assumptions, especially given the 'unrealism' of many of the assumptions[5], as pointed out by Kaldor in section 2.1 above. His preferred alternative is the Kaldorian approach of starting from stylised facts; this approach characterises many of his publications, the prime example being Godley (1999c), but also the Levy Institute Stategic Analysis series, reviewed in section 2.3.3.2 below.

8. The Preference for Analytical Solutions; Godley made extensive use of computational methods and simulation to solve models, giving the

[4] For example, in the passage cited on page 24

[5] For example, in the passage cited on page 24

> modeller freedom to incorporate more realism such as non-linear processes and path dependencies, and to freely explore disequilibrium dynamics.

This is not an exhaustive list, but quite representative of the main objections to the standard model as Godley saw it; it highlights specific areas where SFC provides an alternative to the standard model. Other, more systematic critiques from a post-Keynesian perspective include Arestis (2009), Kriesler & Lavoie (2007), Arestis & Sawyer (2011a), Felipe & McCombie (2010), Lavoie (2014) among many others.

Godley's alternative to the standard model is defined in the following passage which explains how he thought a monetary production economy functions,

> the 'post-Keynesian' or 'structuralist' approach derives originally from those economists who were more or less personally associated with Keynes such as Joan Robinson, Richard Kahn, Nicholas Kaldor and James Meade, as well as Michal Kalecki, although he derived most of his ideas independently. So, far from being a deductive system, the post-Keynesian vision is underpinned by 'stylised facts', recognising the manifest existence of institutions, together with regularities and magnitudes in the economic data which can be checked out empirically. Central to this system of ideas is that, in a modern industrial economy, firms have a separate existence with a distinct set of objectives, for example, to make enough profits to pay for growth-maximizing investment. Rejecting as chimerical the concept of the neo-classical production function, post-Keynesians hold that, in an uncertain world, firms, operating under imperfect competition and increasing returns, must decide how much to

> produce and how many workers to employ, what prices to charge, how much to invest, and how to obtain finance. It will be the pricing decision which, in general, determines the distribution of the national income between wages and profits. And as production and investment take time while expectations are in general falsified, there is a systemic need for loans from outside the production sector which generates acceptable credit money endogenously – in other words (in accordance with common observation) there must exist a banking sector. According to post-Keynesian ideas, there is no natural tendency for economies to generate full employment, and for this and other reasons, growth and stability require the active participation of governments in the form of fiscal, monetary and incomes policy. And it will probably be impossible to derive analytic solutions which describe how economies as a whole evolve, particularly as institutions and behavioural patterns change drastically through historic time (Godley & Lavoie 2007c, p.2).

The points he makes in this passage are of two types, his view of what a modern monetary-production economy is like, his *ontological assumptions*, including the existence of institutions, the view that firms have a separate existence with a distinct set of objectives[6]; the role of uncertainty in decision making (a distinguishing mark of all Keynesian thinking); the endogenous nature of money; imperfect competition and increasing returns; the distribution of the national income through pricing decisions, the need for modelling in historical time; a

[6]That "firms have a separate existence with a distinct set of objectives" is a specific illustration of his broader assumption about the existence of institutions (p.31) in which he is describing the 'post-Keynesian' or 'structuralist' approach to macroeconomics. It asserts that firms have their own distinctive behaviour which is not "exclusively motivated by the aspirations of individual agents" (p.24).

rejection of both aggregate production functions and the natural tendency for economies to generate full employment, so that growth and stability require the active intervention of governments. These ontological assumptions underlie Godley's post-Keynesian alternative to the standard model, so they underpin the hypothesis under test in this thesis, namely that the flow ratios act through the multiplier to drive national income under the stabilising influence of the stock-flow norms. However they are only indirectly implicated in the equations of the model in this thesis which are econometric relations between time series in a highly aggregated three-sector model which concentrates on identifying long-run cointegrating relationships within the three-sector model to try to draw conclusions about the action of the flow and the stock-flow ratios; this is in contrast to the behavioural equations of a 'theory-first' model.

The other type of statement was about how we should go about studying the economy, his *methodological assumptions*, including that the macroeconomics cannot be a deductive system, his preference for reasoning from stylised facts and from empirical regularities and magnitudes in the economic data and a de-emphasis on analytic solutions.

The influence of Kaldor comes through in these assumptions including his growing concerns about the methodological "cul-de-sac"into which economic theory had been led (Kaldor 1975) as well as his objections to 'equilibrium economics' (Kaldor 1972). Godley specifically mentions stylised facts in the cited passage which is a direct reference to Kaldor (1957 1961)., and while his understanding may have deepened during his working life, the same fundamental views are being expressed in his writing right up to his latest publications (Godley & Lavoie 2007c, Godley *et al.* 2008), starting from the time at the

Department of Applied Economics.

2.1.2 The New Cambridge Hypothesis

The Department of Applied Economics had been founded in the immediate post-war period largely on the initiative of Keynes who is quoted in Moggridge (1980) as saying in 1944 that "theoretical economics has now reached a point where it is fit to be applied". Its first director was Richard Stone who established the emphasis on empirical work in his vision and objectives for the department,

> The Department will concentrate simultaneously on the work of observations, i.e. the discovery and preparation of data; the theoretical appraisal of problems, i.e. the framing of hypotheses in a form suitable for quantitative testing; and the development of statistical methods appropriate to the special problems of economic information. (cited from Pesaran & Harcourt (2000, pp.149-150))

Godley embraced these objectives, but was anxious to bring economic issues to a wider public; one of the reasons he gave for the move to Cambridge was to continue in public, work that he had previously been obliged to carry out in secret, and hence to raise the level of public awareness of economic policy. One means of achieving this was to form the 'Cambridge Economic Policy Group' (CEPG) which issued a yearly publication, the Cambridge Economic Policy Review (CEPR) with analysis and forecasts for the UK economy between February 1975 and December 1982 (Cambridge Economic Policy Group 1975).

The group acquired the name 'New Cambridge' after a public intellectual altercation with some representatives of 'old Cambridge' (recounted in Mata (2006)) over their unconventional policy proposals (Cripps *et al.* 1976). The

New Cambridge group are known for three main innovations,

1. The Three Balances equation, which is an ex-post accounting identity which emerges from the national income accounts. It simply requires that the financial balances of the three sectors of the economy should sum to zero, "measured at current prices, the government's budget deficit less the current account deficit is equal, by definition, to private saving net of investment". Although Godley later described the realisation of this identity as a 'Damascene moment' (Godley & Lavoie 2007c, p.xxxvi), and it doubtless was for him, it's not unreasonable to expect that others familiar with the national income accounts had experienced that realisation before that moment.

2. The Twin Deficits hypothesis, although this was originally proposed by Polak (Polak 1957). It follows from the three balances equation and the assumption that the private sector tend to be roughly in balance, an assumption that found empirical support (discussed further below). But if the private sector balance approximates to zero, the three balances identity requires that the other two sectors should either have zero balances as well, or balances that are equal and opposite. If the private sector is in balance, then traditional 'Keynesian' attempts to boost the economy by increased government spending would only worsen the current account deficit, which is the twin deficits scenario.

   According to Dos Santos & Macedo e Silva (2010, p.22), "New Cambridge economists were vocal advocates of Polak's twin deficits hypothesis (even though for different reasons)". They justify this by appeal to a classification set out by Barbosa-Filho *et al.* (2006) who assert that three main 'schools of thought' have discussed aggregate financial balances: the "Ricardian" rational expectations (RE) approach of Barro (1974) and others; the 'Twin-Deficit' (TD) approach associated, among others, with Polak (1957); and the heterodox structuralist external gap (SG) view.

These three 'schools' suggest three different causality structures for the three balances. The TD approach tends to think of the private financial balance as largely independent of the other two. Any attempts by the government to use fiscal policy to expand the economy would therefore imply an increase in the current account deficit (or a reduction in the current account balance). In the RE approach, on the other hand, it is the current account balance that is largely independent of the other two. In particular, any attempts by the government to use fiscal policy to expand the economy would imply a reduction in the private financial balance (in anticipation of future increases in taxation necessary to keep government finances inter-temporally solvent). Finally, the SG story is similar to the RE story in assuming the current account balance as largely independent of the other two, even though for quite different reasons. Structuralists do not assume full employment of the labor force, [...] the current account independence in SG models has little to do with agents solving inter-temporal maximization problems with full knowledge of future events, and a lot to do with structural factors (such as deteriorating terms of trade and/or lack of competitive

> advantages in external markets for goods and services, and/or imperfections in international financial markets) that imply that private and government financial balances must sooner or later adjust so as to reduce too high a current account deficit Dos Santos & Macedo e Silva (2010, p.11).

This latter view contains aspects of the "Balance of Payments constrained Growth hypothesis" (Thirlwall 1979), further discussed in section 4.1.2.1.

3. The Aggregate Private Expenditure function, which is an empirical relationship between total private expenditure (consumption plus investment) and disposable income, founded on what came to be known as 'The New Cambridge hypothesis', elaborated further below. Aggregation of consumption and investment into a single quantity, private expenditure becomes a convenience when dealing with three sector models with the private sector treated as a single entity, but ran counter to the accepted practice of analysing household consumption and firms' investment as separate functions (Blinder 1978). Martin (2012) discusses some justifications including that households 'pierce the corporate veil' meaning that household saving decisions offset corporate retained earnings. More mundane possibilities include miss-specification of micro-relationships and data measurement errors. Godley's own justification seems to rest on the small stable private sector balance and the difficulties of measuring consumption and investment separately,

   > .. as the stock of liquid financial assets does not, *as an empirical matter*, fluctuate wildly and is not high relative to the flow of income, it is acceptable to bypass the specification

> of (several) consumption and investment functions as well as the labyrinthine inter-relationships between the household and business sectors, for instance, the distribution of the national income between profits, proprietors' income and employment income, the retention of profits, and the provenance of finance for investment, [..], the aggregate private expenditure responds in a coherent way to aggregate income, given various assumptions about the future course of asset prices and of net lending to the private sector (Godley 1999c, p.21) (emphasis added).[7]

So, the empirical observation that, in recent decades the UK private sector had run a small but stable balance, a Kaldorian stylised fact, came to be the foundation of much of their results, starting with the New Cambridge hypothesis and the aggregated private expenditure function, with the twin deficits scenario as a further consequence. It also marked a point of departure from the 'old Cambridge' Keynesians since, in the traditional Keynesian model the savings *rate* is fixed — it's the complement of the propensity to consume — so the *volume* of savings varies with income. But if the private sector balance is stable, the savings volume is stable so the rate must be adjusting. They later posited the existence of a target ratio of net financial assets to disposable income for the private sector as a whole, a *wealth-income norm* to explain this (Godley & Cripps 1983, p.41). Changes in the aggregate savings rate were the means of keeping the wealth-income ratio converging upon its target level (the wealth-income norm). The first formal statement of the consequences of the 'small and stable balance' was the *New Cambridge hypothesis*,

[7] and yet he rejected this aggregation in his book with Marc Lavoie "households and production firms take entirely different decisions" (Godley & Lavoie 2007c, p.25)

> [It is argued that] there exists a functional relationship which can be estimated with a reasonable degree of accuracy between total private expenditure (including investment) on the one hand and total private income (including profits and certain kinds of borrowing) less total tax payments on the other (Cambridge Economic Policy Group 1975), cited from Cripps *et al.* (1976, p.46).

This finding was later given further empirical support from the US by Ruggles & Ruggles (1992) and their 'dual capital formation' hypothesis. They were studying patterns of household and business saving. They re-define household saving as the excess of income over expenditure on *nondurable* consumption goods and with their revised definitions of saving and consumption find that, in the US between 1947 and 1989, household savings is roughly equal to expenditure on durable goods, i.e. on household capital formation[8]. In respect of firms, they also find that total business saving, i.e. retained earnings, is roughly equal to total business capital formation (investment). This finding that, in the US also, the private sector balance was small and stable (actually zero under these revised definitions) not only lends support to the New Cambridge hypothesis, but also undermines the generally accepted 'functional view' that households are net savers and their surplus is used to fund investment by businesses who are net borrowers, to be replaced by a 'sectoral' view that household saving funds household capital formation and business saving funds business investment.

[8] They actually made several *corrections* to the conventions in the national income accounts: 1. they separate households from non-profit organisations serving households (NPISH); 2. they remove the fictitious housing sector which arises because NIPA treats homeowners living in their own homes as businesses' renting out their homes to themselves; 3. they adjust for the fact that employer contributions to pension funds are treated as being paid out to individuals, while at the same time the acual pension payments are not counted in individual income; 4. they separate consumption expenditures into durables and non-durables, treating expenditure on durables as household capital formation' (Ruggles & Ruggles 1992, p.119-126)

These relationships hold in the long-term; in the short term, finance is required to smooth out mismatches in the savings and investment flows.

There were implications for fiscal policy to be inferred from this hypothesis,

> ...that this enables an inference to be made (given the level of public expenditure and the conduct of credit policy) about the full-employment yield of the tax system which is the necessary but not sufficient condition for simultaneously achieving, over a sustained period, any pair of targets for the current balance of payments and the level of employment; and that the inference (in so far as it relates to underlying trends) can be made independently of external conditions such as the terms of trade (ibid.p.46)

The inference concerning the full-employment tax-yield given the level of public expenditure leads to the definition of the *fiscal stance*, to be discussed below (section 2.2.1.1), which was the first necessary but not sufficient condition for achieving targets for the the balance of payments and the level of employment;

> ...but an appropriate setting of tax rates under this set of rules in no way ensures that both targets will be reached; for this to be achieved it is necessary that the economy should succeed in selling enough exports relative to imports (ibid.p.46).

defines the other necessary condition, the level of exports relative to imports which leads to the *trade ratio*, also to be defined in section 2.2.1.1. The fiscal stance and the trade ratio are the key ratios in the economic dynamics to be studied in subsequent chapters.

2.1.3 The Economics of Stocks and Flows

It was in Godley and Cripps' book *Macreoeconomics*, published in 1983, that the existence of a target ratio of net financial assets to disposable income for the private sector as a whole, a *wealth-income norm*, was proposed (Godley & Cripps 1983). This idea of a wealth-income norm for the private sector was generalized into an *axiom* of their macroeconomics in which *stock-flow norms* regulate key flows throughout the economy, other examples being the inventory-sales norm and the public sector debt-GDP ratio. The axiom states that "stock variables will not change indefinitely as ratios to related flow variables" (Godley & Cripps 1983, p.41). Stock-flow norms will be defined in section 2.2.1.3. Building on the stock-flow axiom, the book attempts to put forth a very simple explication of how *whole economic systems* function, which they characterized as a 'monetarist' financial system (based on the behaviour of stocks of money, financial assets and debts) driving a 'Keynesian' flow system based on the response of expenditure to income. The objective was to correct what they perceived to be a deficiency in the macroeconomic models of the time, including their own, that they tended to ignore constraints which adjustments of money and other financial stocks impose on the economic system as a whole (p. 16).

These constraints of stocks of assets and liabilities on current expenditure flows became a theme in much of the post-Keynesian writing after Keynes. Keynes' model in the General Theory was a short-run model, there are no changes in stocks. Keynes justified this by saying that the time interval was so short that the effects of changes in stocks could be ignored. Robert Solow, commenting on Godley's models at a Cambridge conference to mark the centenary of Keynes' birth, expressed the opinion that,

> Perhaps the largest theoretical gap in the model of *The General Theory* was its relative neglect of stock concepts, stock equilibrium and stock-flow concepts. It may have been a necessary simplification for Keynes to slice time so thin that the stock of capital goods, for instance, can be treated as constant even while net investment is systematically positive or negative. But those slices of time soon add up to a slab, across which stock differences are perceptible. Besides, it is important to get the flow relationships right, and since flow behaviour is often related to stocks, empirical models cannot be restricted to the shortest of short runs (Solow 1983, p.164).

Two of the post-Keynesian economists most credited with developing an economics incorporating stocks and flows are Minsky (Minsky 1957ba 1964 1982 2004) and Tobin (Brainard & Tobin 1968, Tobin 1982).

Minsky is most associated with the interdependence of financial stocks and flows which underpin his *Financial Instability Hypothesis* (Minsky 1986). He considered that a capitalist economy could be viewed as a set of interrelated balance sheets of economic agents; items in the balance sheets set up cash flows, assets generate inflows, liabilities generate outflows, which are generally contractual commitments. Different structures of assets and liabilities and their liquidity result in differing levels of risk, from hedge finance where cash inflows are sufficient to cover both interest payments and repayment of the principal, through speculative finance where inflows cover the interest but not the principal, the debt needs to be rolled over, to Ponzi finance, where inflows don't even cover interest payments and require continual re-financing to meet day-to-day requirements. During periods of stability, the clamour for greater returns increases agents' tolerance of risk, leading to a move from hedge to speculative and eventally to Ponzi financing — stability generates instability. (Minsky 1986). The implications for the 'real economy' of agents' financial structures need to be recognised in order to understand the contagion that spreads throughout the economy during financial crises where financial instability spills over to affect output and employment. Capturing the financial side of the economy is therefore a necessary requirement for success in macroeconomic modelling. This requirement to capture the financial and the 'real' economy in models was clearly expressed by Robert Solow, at the Cambridge conference referred to above,

> The modern economy generates a wide — and changing — menu of financial assets that are imperfect substitutes for one another on both the supply side and the demand side. There are as many interest rates as assets. A complete Keynesian model must certainly contain a lot of portfolio theory; it will have to model asset exchanges as thoroughly as exchanges of goods and services. This vein has been most thoroughly mined by James Tobin as summarized in his Nobel Lecture (Tobin 1982), I would hope Godley could follow suit (Solow 1983, p.165).

James Tobin was the leader of a group that came to be known as the 'New Haven' school, being based at Yale and was also Director of the Cowles Commission, see below, p.88.

Tobin is recognised for many contributions to Keynesian economics, but particularly relevant to SFC modelling is his work on portfolio theory and the macroeconomic impacts on the 'real economy' of portfolio allocation decisions.

His modelling method has often been called the 'pitfalls approach' in a reference to a seminal paper, Brainard & Tobin (1968). The pitfalls they refer to are the simplifications that modellers have to make in order to cope with the complexities of the interdependencies between asset markets and markets for goods and services in the 'real economy'. They are pleading for a 'general disequilibrium' framework for the dynamics of adjustment to a 'general equilibrium' system (p.106).

It will later be argued that the modern SFC models owe as much to Tobin as to Godley, something that Godley is perfectly willing to admit, "My debt to Tobin is enormous; I could not possibly have made this model without his work, particularly on asset choice" (Godley 1996, p.3). This can be seen in Backus *et al.* (1980) which is a fully developed model in the tradition of the New Haven school which exhibits most of the features of the later SFC models — a tableau presentation, five economic sectors, integration of the financial and real economy and full consistency of stocks and flows.

The principles behind the integration of monetary and 'real' models referred to by Solow above, were summarized in Tobin's Nobel prize lecture in 1981 (Tobin 1982, p.172),

> The principal features that differentiate the proposed framework from the standard macromodel are these:
>
> 1. Precision regarding time. A model of short-run determination of macroeconomic activity necessarily refers to a slice of time. It is one step of a dynamic sequence, not a repetitive equilibrium into which the economy settles.

2. Tracking of stocks. An essential part of the process is the dynamics of flows and stocks, investment and capital, saving and wealth, (...) It is not generally defensible to ignore these relations on the excuse that the analysis refers to so short a time that stocks cannot change significantly.

3. Several assets and rates of return. The traditional aggregation of all nonmonetary assets into a single asset with a common interest rate does not permit analysis of some important policies (...)

4. Modeling of financial and monetary policy operations. Too often macroeconomic models describe monetary policy as a stock M whose time path is chosen autonomously by a central authority, without clearly describing the operations that implement the policy (...) What transactions are the sources of variation of money stocks makes a difference, depending on how they alter the wealth and portfolio positions of economic agents.

5. Walras's Law and adding-up constraints (...)[9].

Here we see some of the same themes as discussed in section 2.1.1 above concerning Godley's macroeconomic assumptions — a realistic treatment of time, tracking of stocks and flows, integration of the monetary and the 'real' economy, adding-up constraints or full-accounting consistency as Godley would have put it. The economic mainstream did not heed Tobin's advice or pursue

[9] This is generally construed in a post-Keynesian context to capture the zero-sum requirement for rows and columns of the matrices.

his programme, but Godley did, in the light of Solow's exhortation to "follow suit", as the next section will demonstrate.

2.2 Ratio Analysis and Economic Dynamics

The term 'ratio analysis' is not familiar in macroeconomics but the activity itself is widely used. Ratios are an effective way of scaling and assessing relative quantitative magnitudes; it is common in all manner of analysis. Ratios give a way of providing a meaningful scale to a quantity where the absolute quantity on its own may be difficult to judge. A common example arises in the way the news media often report the profits of large companies; big numbers of pounds, dollars, euros etc intending to impress or shock; but to decide whether a company profit of £x bn is a lot (or not), it needs to be set in relation to other quantities — a margin ratio (profits to sales), a profitability ratio (profits to shareholders funds) which not only makes the results of that company more meaningful, but also allows more meaningful comparison of results with other companies.

In economics, many quantities are routinely expressed as percentages of GDP or per capita; concepts like the capital-output ratio, the wage share, the savings rate are part of the language and precede the advent of empirical economics. Klein & Kosobud (1961) is an early investigation into the question of whether macroeconomic ratios are in the nature of fundamental parameters which could lead to the simplification of theory, or just simple quotients where statements about the ratio have no added value over simple statements about the numerator and denominator separately. The authors were looking for the 'great ratios of economics' and, using data from 1900-1953 for the US, looked at,

1. the savings-income ratio
2. the capital-output ratio
3. labour's share of income
4. income velocity of circulation
5. the capital-labour ratio

They were constructing a global model of growth and wanted to see whether an integrated set of indicators could give an overall picture of the state and direction of movement of the total economy, not unlike the later work of Godley. They drew conclusions about the behaviour of the individual ratios but their place in the global model remained 'work-in-progress'. This work was 'brought up to date' in Mills (2009) who used more recent econometric techniques aimed at identifying stochastic trends as well as the linear trends of Klein and Kosobud and extended the scope to include current data. The work on stochastic trends built on a similar study in King *et al.* (1987), an empirical study of the shifts in stochastic trends underlying several key data series in postwar US data. Kaldor's original stylised facts, referred to in section 2.1 above, were all expressed as ratios which were either roughly stationary, or growing at a steady rate.

2.2.1 Godley's Macroeconomic Ratios

While the examples above demonstrate that *ratios* have always been widely used in *analysis*, Godley took it a step further, arguably making *ratio analysis* a discipline in itself. He used two broad groups of ratios — what could be called the *flow* ratios and the rather better known *stock-flow* ratios — and he used these in combination to understand how they affected the dynamics of a macroeconomy. The flow ratios primarily affect the balances of transactions between the sectors of the economy. The stock-flow ratios capture the effect of transactional flows on stocks of assets and liabilities and have longer term implications for economic stability; some stock-flow ratios exhibit a tendency, after any transient disturbance, to revert to stable values over time; such ratios are treated as *stock-flow norms*.

The flow ratios are defined in the next section and their connection to the multiplier is discussed in section 2.2.1.2; the stock-flow ratios are introduced in section 2.2.1.3 and the way they combine to affect the dynamics of the economy is discussed in section 2.2.2.

2.2.1.1 The Flow Ratios

The first group of ratios, the *flow ratios* emerged from the New Cambridge work on the three balances identity which was first introduced in section 2.1.2. It says that "*measured at current prices*, the government's budget deficit less the current account deficit is equal, by definition, to private saving net of investment." (Godley & Lavoie 2007c, p.xxxvi). It is an identity that derives from the definitions in the national income accounts (OECD 2008),

$$C + S + T \equiv Y \equiv C + I + G + (X - M)$$

where Y is national income, C is aggregate consumption, S is aggregate saving, T is total taxes, I is aggregate investment, G is total government expenditure,

X is total exports and M is total imports. After some regrouping this yields,

$$(S - I) + (T - G) \equiv (X - M)$$

The three expressions in brackets are the balances of each of the three sectors. The conditions for balance of any one of the sectors is just that the corresponding term is zero.

If $T - G = 0$ in this model, there will be no movement of financial assets out of the public sector; if we use the relation $T = \theta Y$, where θ is the average tax rate, then the balance condition becomes $Y = G/\theta$; the quantity G/θ is the *fiscal stance* (Godley & Cripps 1983, p.111) (Godley & Lavoie 2007c, p.72). When GDP is equal to the fiscal stance, the public sector is in balance and there is no change to the stock of public sector financial assets. If $Y > G/\theta$, taxes exceed government expenditure which is a contractionary fiscal stance since the government is taking more out of the economy in taxes than it is injecting through government expenditure; conversely, if $Y < G/\theta$ the fiscal stance is expansionary.

Balance in the foreign sector follows an exactly similar pattern, i.e. $X - M = 0$ and using the relation $M = \mu Y$, where μ is the average propensity to import, then the balance condition becomes $Y = X/\mu$; the quantity X/μ is the *trade ratio* (Godley & Cripps 1983, p.296) (Godley & Lavoie 2007c, p.179) and is also known as Harrod's foreign trade multiplier (Harrod 1939). When GDP is equal to the trade ratio, the foreign sector is in balance and there is no change to the stock of net foreign assets. If $Y > X/\mu$, imports exceed exports and the economy is running a current account deficit. This has a contractionary effect on the domestic economy since it is effectively exporting demand; conversely, if $Y < X/\mu$, exports exceed imports and the economy is running a current account surplus. This is an expansionary trade ratio, the economy is importing demand since foreigners are demanding goods produced in the domestic economy.

The combined fiscal and trade ratio (CFTR) (Godley & Cripps 1983, p.296) (Godley & Lavoie 2007c, p.179), as the name suggests, combines the two. It measures the combined inflow or outflow to the private sector from the other two, $CFTR = (G + X)/(\theta + \mu)$. When the private sector is in balance ($CFTR = 0$) so national income is equal to the CFTR and there is no change to the stock of private sector financial assets. In this situation, it's possible that the other two are also in balance, $G/\theta = X/\mu = 0$, or both the public and foreign sectors have equal and opposite imbalances, the twin deficits situation (defined in section 2.1.2, p.35).

These ratios will be studied further by means of empirical data in chapter 4 on Macroeconomic Ratios.

2.2.1.2 The Flow Ratios and the Multiplier

The flow ratios can be viewed as expressions of a multiplier; it was mentioned above that the trade ratio is the same thing as Harrod's foreign trade multiplier. Starting from a balanced trade condition, $Y = X/\mu$, Harrod determines the income response to a change in exports to be $\Delta Y/\Delta X = 1/\mu$. Similar mulipliers could be expressed from the fiscal stance and the CFTR; consequently, Leite (2015) considers the three flow ratios to be *partial multipliers*, he shows how they can be combined to form what he calls a *complete multiplier*.

Leite derives his complete multiplier from the full statement of the income-expenditure identity of the national income accounts, separating terms into 'autonomous', i.e. independent of income, and 'income dependent' and deriving the multiplier from their ratio. The full statement of the income-expenditure identity is

$$C + S + T \equiv Y \equiv C + I + G + (X - M)$$

where investment I, government expenditure G and exports X are treated as autonomous quantities, while saving S and imports M are 'induced' quantities that can be expressed as functions of income Y. Consumption C has an autonomous and an induced component, $C = C_0 + C_1 YD$ where YD is disposable income $Y - T$. The expressions for the induced components are $T = \theta Y$, $M = \mu Y$ where θ is the average tax rate and μ is the average propensity to import. From the left hand side of the national income identity, $Y \equiv C + S + T$, we get $C + S = Y - T = YD$, so saving S can be expressed as $YD - (C_0 + C_1 YD)$, and by letting $YD = (1 - \theta)Y$, saving becomes $S = -C_0 + (1 - C_1)(1 - \theta)Y$. It is now possible to write an expression for Y with all the autonomous components of expenditure in the numerator and the induced components in the denominator,

$$Y = \frac{C_0 + I + G + X}{1 - C_1(1 - \theta) + \mu} \tag{2.1}$$

Leite calls this the expression of the complete multiplier, the multiplier being the reciprocal of the denominator. This correspondence between Godley's flow ratios and the expenditure multiplier provides a link to the dynamics since the settings of the flow ratios drive changes in income through the multiplier (Leite 2015, p.515).

The multiplier concept has spawned a large theoretical and empirical literature (Leite (2015, p.512) provides a summary), and multipliers have taken many forms, "it would be extremely unfortunate if the multiplicity of multipliers were to be regarded as a defect of the analysis, when in fact it is rather a tribute to the flexibility of the concept" and "it is not so important which multiplier is used as that it be matched with the appropriate *multiplicand*'' (Samuelson 1942, p.586). The global financial crisis has brought some renewal of interest in the multiplier concept and a re-examination of the magnitudes of multipliers. Leite (2015, p.512) lists many post-crisis empirical studies aiming to measure the magnitude of fiscal multipliers. Spilimbergo *et al.* (2009) is an IMF stafff report issued in the wake of the crisis summarising many published studies up to that time. The studies find widely varying values depending on many different factors including survey methodology, data source, country, controls for other variables etc. They cite a historical 'rule of thumb' (using the definition $\Delta Y/\Delta G$ and assuming a constant interest rate) as a multiplier value of "1.5 to 1 for spending multipliers in large countries, 1 to 0.5 for medium sized countries, and 0.5 or less for small open countries''(p.4). Most of the studies find multipliers in the range 0 to 1, although it's interesting that some of the studies, e.g. Romer & Romer (2008), for the US find values of 1.2 - 2.7, with a cumulative effect over two years of 4.0. The wide variation in the results may be due to the underlying assumptions in the studies, bearing in mind the 'New Consensus' assumptions about the efffects of fiscal policy discussed earlier on page 28. For example, one of the studies (H.M.Treasury 2003), finding very low values of multipliers for European countries uses the EU Commission's QUEST model, a DSGE model incorporating those same assumptions.

The reason for this extended discussion of multipliers is that it is central to the dynamic model that is assumed to underly Godley's macroeconomics in which the flow ratios acting though the multiplier drive changes to national income. The process is central to the research question (p.15) and will be developed in more detail in Section 2.2.2.

2.2.1.3 The Stock-Flow Ratios

The flow ratios capture the conditions for transactional balance in the three sectors; the existence of an imbalance means that there is a flow of financial assets between the sectors leading to changes in stocks of assets. There is a relationship between flows and stocks, imbalances between inflows and outflows will lead to changes in stocks, and conversely, stock levels can affect related flows. This defines a mutual 'feedback loop' between stocks and related flows that can be captured in stock-flow ratios; certain ratios constitute stationary relationships and hence qualify as *norms*.

The authoritative source on stock-flow norms is Godley & Cripps (1983); their analogy with the river system flowing into a lake was discussed on page 13. Similarly, if the flow of sales by a merchant is constant, his inventory level will not rise or fall indefinitely. If the flow of income is constant, holdings of money will not change indefinitely. The levels at which stocks and flows achieve a stable balance becomes a *norm*. It is not necessary to assume that in reality the norms are entirely invariant, it is their overall stability that is important. The stability of norms is entirely consistent with fluctuations in actual stock-flow ratios. Even when the norms change, perhaps due to some underlying structural change in the economy, the consideration of stock-flow and flow-flow relationships and the logical connections between them gives a powerful technique for analysing system dynamics and the transition to new system states.

A stock-flow ratio is simply the ratio of a stock variable to one of its associated flow variables, so in any particular model there could be at least one stock-flow ratio for each stock variable in the model, although not all of these ratios will be equally useful. In a three sector model of an economy such as has been the subject of discussion in section 2.1.2 above on the New Cambridge hypothesis, the stock of net financial assets for each sector was implicitly the stock variable being considered. This leads to three stock-flow ratios, the ratio of private sector net financial assets to diposable income, the ratio of public sector debt to GDP and the ratio of net foreign assets to GDP. Other ratios could be proposed, but these have been widely used in Godley's models (Godley & Cripps 1983, Godley 1999c, Godley & Lavoie 2007c). Stock-flow ratios will be studied in more depth in chapter 4 with reference to US empirical data and in chapter 5 for their dynamic effects.

2.2.1.4 Competing Explanations of a Stock-Flow Norm

The observation that these stable relationships exist between some stocks and flows demanded an explanation; Godley & Cripps (1983) proposed that, in the case of the private sector wealth-income ratio, private sector agents had a *target* level of financial wealth relative to disposable income. Shaikh (2012) considered this to be merely an attempt to find a theoretical justification for the empirical finding that the private balance tends to be small and stable. The question that arises is whether the existence of stable stock-flow norms is a *behavioural* phenomenon, i.e. one that can be traced to the behaviour of individual agents, or a *systemic* phenomenon, something that only exists at the aggregate level, an *emergent property*, in the complex systems sense (to be discussed in chapter 3).

What exactly *is* a stock-flow norm? Do individual households and businesses have a target wealth-income ratio in mind that governs their expenditure and saving decisions? Such an explanation, in terms of the actions of individual agents, would mean that stock-flow norms are a *behavioural* phenomenon. In relation to stock-flow norms, the behavioural interpretation would be an attempt to provide *microfoundations*. In their original statement of the stock-flow axiom, Godley & Cripps (1983, p.42) ask "is it a postulate about how groups of people actually behave?" but add the observation that "the assumption of constant aggregate stock-flow norms may be consistent with a large number of different patterns of individual behaviour" and "by stating the conditionality of the models ... on the stock-flow axiom we formally exonerate ourselves from the need to provide further microeconomic foundations" and conclude that "the formal status of the axiom is akin to that of an *exogenous variable*, it is something which the model itself cannot explain". From the originators of the concept of stock-flow norms that sounds like an argument against the behavioural interpretation[10].

Alternatively, an explanation of stock-flow norms as an *emergent* property that only acts at the level of the whole sector would mean that stock-flow norms are

[10]The degree to which firms and households are consolidated in this analysis depends on one's purpose. In the LCH they are not consolidated, it is a theory of household behaviour. In the three sector model developed later they are totally consolidated since the ratio applies to the private sector as a whole, following the Ǹew Cambridge' aggregation of consumption and investment into a single private expenditure funcion.

a *systemic* phenomenon, something that is only visible at the aggregate level not the individual level, and emerges from the composition of the divergent behaviours of countless heterogeneous agents. The latter interpretation is fully consistent with the view of a macroeconomy as a *complex adaptive system*, introduced earlier (p.6) which will be developed further in chapter 3. Arthur (2014) likens an economic system to an endless feedback cycle — the composition of all the diverse individual behaviours results in a set of macro conditions in response to which the individual agents revise their expectations and behaviour, which in turn creates modified macro conditions and so on, ad infinitum. To the extent that *equilibrium* ever occurs in a real macroeconomy, it is a dynamic, churning equilibrium like that of a chemical reaction where the forward reaction is proceeding at roughly the same rate as the reverse reaction leading to an apparent steady state at the macro-level, rather than the static equilibrium of structural mechanics where balanced forces result in complete stasis.

Godley & Cripps (1983) states that there may be many micro behaviours that could lead to the macro emergence of stock-flow norms. One possibility is the *wealth-income lifecycle*, a second, to be explained below comes from the concepts of integral control systems.

The Wealth-Income Lifecycle Modigliani & Brumberg (1954) and Modigliani *et al.* (1980) proposed the *Life Cycle Hypothesis* (LCH) as a response to the failure of the multitude of empirical studies (both time series and cross-sectional) to accurately capture the consumption function proposed in Keynes' General Theory (Keynes 1936); the cross-sectional studies didn't tally with the time series results, and the time series (aggregate) consumption function didn't appear to be stable over a long period, it appeared to be shifting upwards over time; Spanos (1989) gives a detailed account of attempts up to that time to empirically estimate the consumption function. The idea of the LCH is that people make intelligent choices about how much they want to spend at each age, limited only by the resources available over their lifetimes — it's as if they have a budget constraint for a whole lifetime instead of a budget constraint for a single period. By building up and running down assets, working people can make provision for their retirement, and more generally, tailor their consumption patterns to their needs at different ages, independently of their incomes at each age, so consumption is proportional to average income over the life span. But the share of consumption in income is lower for wealthier households — the savings rate rises with income — and the data often show negative savings rates in the lower part of the income distribution. In this way, the wealth of the nation gets passed around; the very young have little wealth, middle-aged people have more, and peak wealth is reached just before people retire. As they live through their retirement, people sell off their assets to provide themselves with an income. The assets shed by the old are taken up by the young who are still in the accumulation part of the cycle. So far this sounds like a micro- story, but it leads to important and non-obvious predictions about the economy as a whole. In an economy with growth, if it is due to population growth, Modigliani and Brumberg assumed that there would be more young people than old, more people would be saving than dissaving, so that the total dissaving of the old would be less than the total saving of the young, and there would be net positive saving. If growth is due to increases in per capita incomes, again Modigliani and Brumberg assumed that the young will be saving on a larger scale than the old are dissaving so that economic growth, like population growth, causes positive saving, and the faster the growth, the higher the saving rate[11]. Irrespective of whether it is population growth or growth in per capita incomes, what matters for saving is simply the *rate of growth* of total income; the *level* of income itself doesn't matter, and poor countries save the same share of their income as rich countries. In an economy with no growth, wealth will just be passed around, no new wealth will be created. Based on this reasoning they asserted that the total wealth in the economy depends on the length of retirement, and in simple cases, the ratio of a country's wealth to its income (its *wealth-income norm*) is half of the average length of retirement, see Modigliani (1966, p.165) for derivation of this result. More generally, the ratio of wealth to income is lower the faster is the rate of growth of the economy, and is at its largest when the rate of growth is zero.

Thus, the LCH provides an alternative explanation for the stability of the wealth-income ratio and explanations for its variation under some circumstances. Modigliani's ratio is an example of a stock-flow norm, although he doesn't use this language; Godley & Cripps (1983) take the concept further by postulating other similar stable norms (debt-income ratios, inventory-sales ratio, etc) but do not cite Modigliani when introducing the concept. Godley & Lavoie (2007c) refers to the 'Modigliani consumption function', i.e. one in which there is consumption out of wealth, but does not refer to the LCH explicitly.

Another theory of consumption that is closely related is the *permanent income hypothesis* (PIH) (Friedman 1957). It relies less on considerations of wealth, concentrating on income flows; it distinguishes between 'permanent income'

[11]These assumptions about the distribution of income may not hold in the ǹeoliberal period' when the bulk of income growth has gone to the top percentiles, incomes of the rest have been flatlining.

and ‘transitory income’ such as windfalls; consumption is postulated to depend on permanent income not transitory income. The PIH makes assumptions about expectations of future income that are not required by the LCH and does not explicitly treat accumulation of wealth so, although it is the dominant theory of consumption in mainstream economics, it does not contribute to the concept of stock-flow norms, and will not be discussed further.

The Integral Control Process Phillips (1954 1957) apply the principles of control systems theory to the regulation of economic systems. In such systems there is a target and an actual level of a variable of interest, and the difference between them is a deviation or ‘error’. In order to close the target-actual gap, a change can be made to one of the controlled variables. The way this change to the controlled variable is calculated falls into three categories, proportional, integral or derivative control which may be applied separately or in combination according to the characteristics of the system. With proportional control, the ‘correcting’ input is just proportional to the error. Under integral control, the applied correction is related to the integral of the errors over some preceding time interval, and with derivative control, the correction is related to the rate of change of the error. Each of these mechanisms has specific characteristics that are appropriate to different types of systems and these are explained in Phillips (1954).

These concepts can be applied to the aggregate private expenditure function, by considering that private expenditure is the quantity that economic agents can control, and they are adjusting it according to the gap between it and private disposable income. This is quite a plausible scenario, private disposable income (yd) is, for most agents, a given, at least for extended periods of time.

They can, however, exert some degree of control over private expenditure (px), and it is the gap between them ($yd - px$), which corresponds to saving, that they are monitoring. Of the three control regimes mentioned above, the one that is applicable here is a proportional-integral scheme. Since we are using discrete rather than continuous time, the integral is replaced by a summation and the correcting equation for px is,

$$px_t = k_1(yd_t - px_t) + k_2 \sum_{t_1}^{t_2} (yd_t - px_t)$$

The first term is the 'proportional' element and the second is the 'integral' element, meaning that private expenditure is some proportion of the gap between yd and px (the private sector surplus) and some other proportion of the accumulated surpluses from previous periods, which corresponds to financial wealth.

For example, assuming values for $k_1 = 2$ and $k_2 = 0.75$, and that $yd_t = (1+g)yd_{t-1} + \epsilon_t$ where $g = 0.03$ is the rate of growth and ϵ_t is a zero-mean random error, figure 2.2.1 shows the evolution of yd, px and fa over 100 periods. The lower plot shows the stock-flow ratio fa/yd.

The particular values in this example are plausible but not important in themselves, the point is to show that a stable stock-flow norm can *emerge* from such a system without individual agents being aware of it — they are simply controlling their expenditure in response to the gap between income and expenditure.

Summary: Competing Explanations for Stock-Flow Norms

The purpose of this section has been to show that it is not necessary to assume

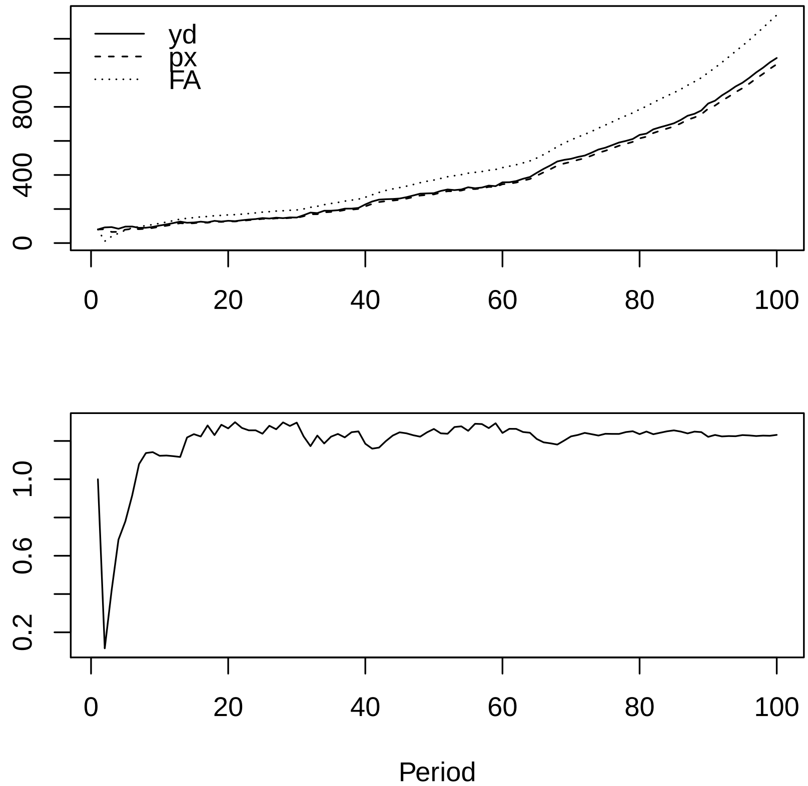

Figure 2.2.1: A PI control scheme for Income and Expenditure and the emerging stock-flow ratio

microfoundations for the existence of stable stock-flow ratios and that they can successfully be explained as *emergent* properties of the dynamic behaviour of the economic system. The alternative behavioural interpretation, i.e. that *individuals* have a target value in mind for the ratio is not explicitly stated in any of Godley's writings, but he does suggest that there is a 'target level of a stock' in relation to its flow (e.g. a target level of inventory relative to sales or a target level of wealth relative to income) without actually stating that it is an *individual* target.

Godley & Cripps (1983) states that a stock-flow norm is an exogenous variable – something that cannot be explained (p.42). The possibility that it is an emergent phenomenon is presented here in terms of Modigliani's life-cycle hypothesis and Phillips' proportional-integral mechanism from control theory. It is not being claimed here that one or the other of these is the 'correct' mechanism, they are merely being used as examples to show that there are possibly many explanations of stock-flow norms as *systemic* phenomena.

2.2.2 The Ratios and Economic Dynamics

At the 1983 centenary conference for the birth of Keynes referred to above, Godley, leading the session on "Keynes and the managememt of real national income and expenditure", made the following declaration,

> Any time between 1950 and 1970 I would have confidently attributed to Keynes, as pre-eminently important, the following views about economic policy:
>
> (a) Real demand, output and employment are determined via a multiplier process by the fiscal and monetary operations of the

government and by foreign trade performance

(b) Inflation, though influenced by the pressure of demand, is largely indeterminate in terms of economic variables and therefore, if it is to be controlled, requires some kind of direct political intervention

(c) Fiscal and monetary policies in any one country are potentially subject to important external constraints.

(Godley 1983, p.135).

These statements summarize, not only what Godley thought Keynes thought about the economy, but also capture how Godley thought about it. The hypothesis under test in this thesis is contained in points (a) and (c); it describes a fundamental dynamic which he considers to be the driver of the economy; the "fiscal operations of the government" and the "foreign trade performance" are one half of Godley's ratio analysis — the *fiscal stance* and the *trade ratio* (section 2.2.1.1) work through into real demand, output and employment "via a multiplier process" (section 2.2.1.2), and changes in income lead to changes in stocks of financial assets which are regulated by the "stock-flow norms" (section 2.2.1.3). These three components, the *flow ratios* acting through *the multiplier* leading to convergence through *the stock-flow norms*, combine to form the dynamic process which is illustrated in the little schematic in figure 2.2.2. The flow ratios act as 'drivers' of the economy, they determine the level of the injections from the public and foreign sectors into the private sector, impacting private sector income and expenditure and hence the private sector balance. Any non-zero private sector balance results in a flow of net financial assets between sectors. The willingness of the private sector to hold assets issued by the other two is captured by the stock-flow norms. These act as stabilisers, and the levels of national income, private expenditure and the stock of private financial assets mutually adjust to these norms through the action of partial adjustment processes (to be defined in section 2.2.2.1).

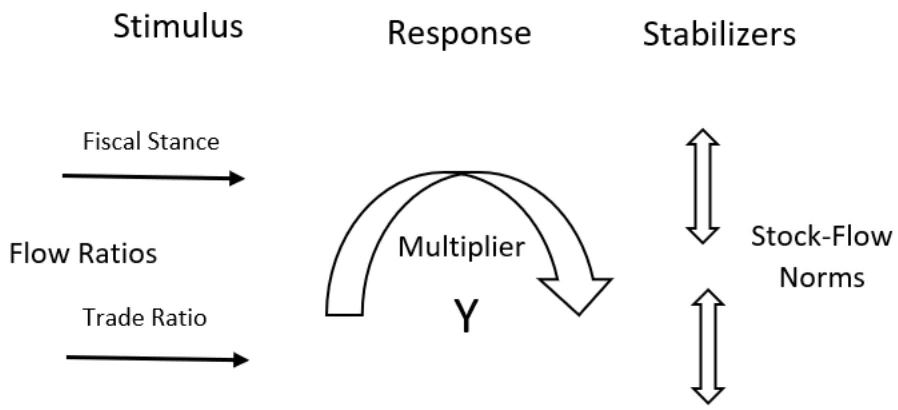

Figure 2.2.2: Schematic of the Ratio-based Dynamic Process

It is the final component of this dynamic — convergence through stock-flow norms — which is the novel aspect and marks a departure from the standard Keynesian approach. As part of his presentation of this process at the Keynes conference referred to above, Godley described "some modifications which have to be made to Keynesian theory if it is to provide a sound underpinning for Keynesian policies", specifically "whereas in Keynes' core model aggregate income brings the flow of saving into equality with investment, in mine the income flow equalizes the demand for financial assets with the stock of debts" (Godley 1983, p.136). This is the point made in section 2.1.2 (p.38) that the Keynesian model has a constant savings *rate*, whereas Godley's model has a constant wealth-income ratio. The reference in point (c) to "important external constraints", presages the existence of the third of the stock-flow norms governing the foreign sector in a three sector economy (introduced in section

2.2.1.3).

The mechanism by which the flow ratios and the stock-flow norms combine to bring about convergence is described in the following passage from the lecture referred to above, in the context of a closed economy,

> Given the fiscal stance (G/θ), so long as aggregate income exceeds its warranted level ($Y > G/\theta$) the tax yield must be such that the government's debt is falling; if income is below the warranted level ($Y < Y_{GT}$), the government's income is less than its expenditure so government debt is rising. Either way Y will converge towards G/θ, accompanied by changes in government debt until it reaches whatever level exactly satisfies the stock equilibrium condition (Godley 1983, p.147)

The "stock equilibrium condition" expresses the balance of disposable income and private sector financial assets required by the wealth-income norm, $FA/YD = \alpha$, where FA is the stock of financial assets, YD is private disposable income and α is the wealth-income norm.

The convergence process is assumed to follow a *partial adjustment process*, to be defined in the next section.

2.2.2.1 Partial Adjustment Processes

Given a stock S and a corresponding flow F, if their ratio S/F is stationary (though not necessarily constant) with respect to time[12], the stationary value defines a stock-flow norm. If the ratio is mean-stationary (although it could

[12]Since the ratio is varying with time, there is an implication that it is a time series, and hence has a constant mean and variance, even though the individual values of the ratio are varying (not constant).

also be trend-stationary), the norm α becomes the mean over some time period of the ratio. As the values of S and F fluctuate under the influence of diverse factors in the environment, the ratio S/F will deviate from the norm α but there is a tendency for the two quantities to adjust in some way so that the ratio re-converges on the norm.

At any point in time, the particular value of the flow F_t defines a *target* level of the stock, ${S_t}^* = \alpha F_t$, and there will be a difference between the target value ${S_t}^*$ and the actual value S_t. This difference, ${S_t}^* - S_{t-1}$ where S_{t-1} signifies the stock level at the end of the previous period (or the beginning of the current period), is a gap that must be closed if the stock is to converge to the norm, $\Delta S_t = {S_t}^* - S_{t-1}$. If that is the case, there will be an induced change in the flow ΔF_t which will be proportional to ΔS_t, $\Delta F_t = \phi \Delta S_t$ where $0 < \phi < 1$. ϕ is called the *speed of adjustment* factor; being positive and less than one means that the convergence process is stable, since changes to the flow in any period will have the same sign as the difference in the stocks and the adjustment in each period will be less than the full amount of the stock difference so convergence will occur over several time periods rather than all at once, hence the name *partial adjustment process*. The time interval required for the convergence is defined by the *mean lag* (see below).

Substituting ${S_t}^* = \alpha F_t$ in the expression for $\Delta F_t = \phi({S_t}^* - S_{t-1})$, gives a general form of a partial adjustment process in terms of the stock-flow norm,

$$\Delta F_t = \phi(\alpha F_t - S_{t-1}) \tag{2.2}$$

When the deviation has been eliminated, $\alpha F_t = S_{t-1} = S_t$, $\Delta F_t = 0$ and the system will be in a full stock equilibrium with new levels of S and F and their ratio restored to the norm α.

The Mean Lag Equation 2.2 describes the relationship between a stock and a single flow, but in most stock flow situations, there will be two flows — an inflow and an outflow. For example, a stock of debt is the accumulated difference between lending and repayments, a stock of wealth is the accumulated difference between income and expenditure, inventory is the accumulated difference between production (or purchases) and sales. The stock-flow norm is usually expressed as the ratio of the stock and whichever of the flows is thought to be the driver of the dynamics; so we have the wealth-income norm since expenditure would normally adjust to income, the inventory-sales norm since production or purchases would normally adjust to sales. When the 'secondary' flow has adjusted to the 'primary' flow, the level of the stock will no longer be changing.

Godley & Cripps (1983, p.64) proves the Mean Lag theorem which states that the mean lag for the secondary flow to converge on the primary flow is equal to the stock-flow norm, so the stock-flow norm fills two roles, it not only provides a target relationship between the stock and the flow, but also determines the speed of adjustment to the target following a deviation.

The following is a demonstration of the mean lag in terms of the partial adjustment process of private expenditure PX to disposable income YD with the stock-flow norm α and private net financial assets FA.

From the assumption that $\alpha = {FA_t}^*/YD_t$, a partial adjustment process can be formed by assuming that in each period the change in wealth is some proportion, ϕ of the gap between the actual level of financial assets FA_{t-1} and the target

${FA_t}^*$,

$$\Delta FA_t \equiv (FA_t - FA_{t-1}) = \phi({FA_t}^* - FA_{t-1}) \tag{2.3}$$

then, by substituting ${FA_t}^* = \alpha YD_t$,

$$FA_t = \alpha\phi YD_t + (1-\phi)FA_{t-1} \tag{2.4}$$

which is a recurrence equation for FA_t.

From the accounting identity,

$$\Delta FA_t = FA_t - FA_{t-1} = YD_t - PX_t \tag{2.5}$$

and the right-hand equality in equation 2.3 we get

$$YD_t - PX_t = \phi({FA_t}^* - FA_{t-1})$$

and again substituting ${FA_t}^* = \alpha YD_t$, arrive at an equation for PX_t,

$$PX_t = (1-\alpha\phi)YD_t + \phi FA_{t-1} \tag{2.6}$$

Repeated subsitution of the recurrence equation 2.4 for FA_{t-1} in equation 2.6 yields the following recurrence equation for PX_t,

$$PX_t = (1-\alpha\phi)YD_t + \alpha\phi^2 YD_{t-1} + \alpha\phi^2(1-\phi)YD_{t-2} + \alpha\phi^2(1-\phi)^2 YD_{t-3} + \ldots + \phi(1-\phi)^{t-1}FA_0 \tag{2.7}$$

When t becomes large $\phi(1-\phi)^{t-1}FA_0 \to 0$, and

$$PX_t \to (1-\alpha\phi)YD_t + \alpha\phi^2 YD_{t-1} + \alpha\phi^2(1-\phi)YD_{t-2} + \alpha\phi^2(1-\phi)^2 YD_{t-3} + \ldots$$

The mean lag is

$$\frac{\sum_{t=1}^{n} c_t \cdot t}{\sum_{t=1}^{n} c_t}$$

where c_t is the coefficient of the t^{th} term.

After some algebraic machinations, it turns out that,

$$\sum_{t=1}^{n} c_t \cdot t = \alpha\phi^2[\frac{1-(1-\phi)^t}{\phi^2} - \frac{t \cdot (1-\phi)^{t-1}}{\phi}] + \phi(1-\phi)^{t-1} \cdot t$$

and

$$\sum_{t=1}^{n} c_t = 1 + \phi(1-\alpha)(1-\phi)^{t-1}$$

As $n \to \infty$, the numerator $\to \alpha$ and the denominator $\to 1$ so the mean lag $\to \alpha$. This is depicted in figure 2.2.3 which is a simulation of the convergence of the mean lag to the stock-flow norm over 20 simulated time periods.

Lance Taylor (Taylor 2008) calls this the 'bathtub theorem', presumably by analogy with the water level in a tub finding a new level after changes to the inflow or outflow. He also says that "in a higher order dynamical system, mean lags break down. The derivative would become a matrix of partials and one

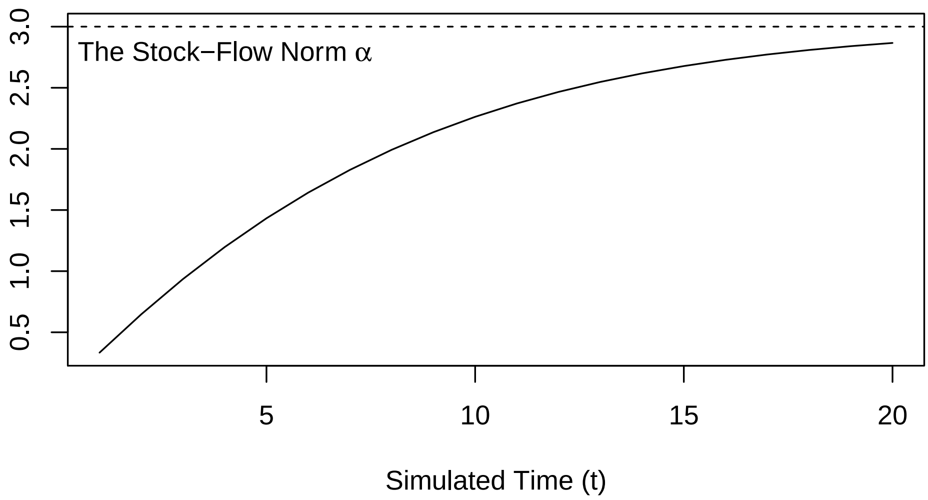

Figure 2.2.3: Simulation of the convergence of the Mean Lag to the Stock-Flow norm with time
Based on simulated data.

would have to examine speed of convergence using matrix methods" (p.647). Martin (2012, p.105) finds that "the response of expenditure to a change in income is subject to persistent overshooting and undershooting".

2.3 The SFC Modelling Methodology

Section 2.1 described the development path of Godley's macroeconomics, from its origins with Keynes and the post-Keynesians, especially Kaldor, then tracing its subsequent evolution, especially through the New Cambridge years, to arrive at a particular view of what a modern monetary-production economy was like and how it should be studied. He was always at pains to contrast his view, which could be called the *alternative model* (page 31), with that of the prevailing mainstream orthodoxy, based largely on neo-classical assumptions

— what he often referred to as the *standard model* (page 24). The differences between the two are set out in detail in the list on page 25 but essentially, the differences are *ontological* — what a modern monetary-production economy is really like — and *methodological* — how we should study it.

Thus, from Godley's point of view, the development of the SFC modelling approach could be seen as a methodological vehicle for capturing the behaviour of a monetary-production economy and, occasionally for highlighting failures, fallacies and paradoxes in the standard model. The ambition for the SFC modelling approach is to empower a modeller to capture those real-life characteristics of the economy, and to do it in a manner consistent with the methodological approach.

The purpose of this section is to trace the development of the SFC approach through the medium of the literature it generated, all the while tracing its features back to the macroeconomics and the methodology of the post-Keynesian alternative to the standard model. Section 2.3.1 presents the model structure and explains how the various parts capture key aspects of the alternative model. Section 2.3.2, with the help of figure 2.3.1, traces the history of the evolution of the approach from the earliest 'Keynesian' models through its dual inheritance with parallel threads via Tobin and the 'New Haven' school and its emphasis on asset allocation and portfolio theory, with the other thread being associated with Godley and the 'New Cambridge' school. These separate threads come together in a 1996 paper (Godley 1996), arguably the first appearance of a model with all the features of the later SFC models in which all the essential elements of the method were present. Section 2.3.3.1 describes what could be considered to be the *SFC core literature*, that is, a set of publications that emerged after

Godley's 1996 paper which apply the assumptions of the alternative model and the SFC methodological approach to the main macroeconomic issues — open economy macroeconomics, fiscal and monetary policy, inflation, growth and the business cycle, banking and endogenous money — culminating in Godley & Lavoie (2007c) which is the authoritative text on the subject. Taken together, they form a base or core which collectively defines the method at the same time as expounding the alternative macroeconomics. Finally, section 2.3.4 summarizes some methodological aspects of the SFC approach arising from considerations of parameterization and model solution, exemplified by the strand in figure 2.3.1 that has been labelled the 'Empirical Models'.

As a note in passing, a brief remark about the name — 'stock-flow consistent' is not a good label for this type of model, it implies that others are not. The problem of consistency between stocks and flows arose when extending the Keynesian short-run model (where stocks are assumed constant) to the medium/long-run (where changes in stocks bcome significant). In a section called "Onomastics" in a recent survey paper on SFC models Nikiforos & Zezza (2017) attribute the name to a paper by dos Santos,

> The name "Stock-Flow Consistent" has existed in the literature for a long time as a reference to models with these characteristics [...] (e.g., Davis (1987)). However, it was only established as a "brand name" after Claudio Dos Santos's PhD dissertation at The New School for Social Research entitled Three Essays on Stock-Flow Consistent Macroeconomic Modeling (Dos Santos 2002).

So stock-flow consistency is certainly a characteristic of these models but not necessarily the defining one. Tobin-Godley models would perhaps have been a

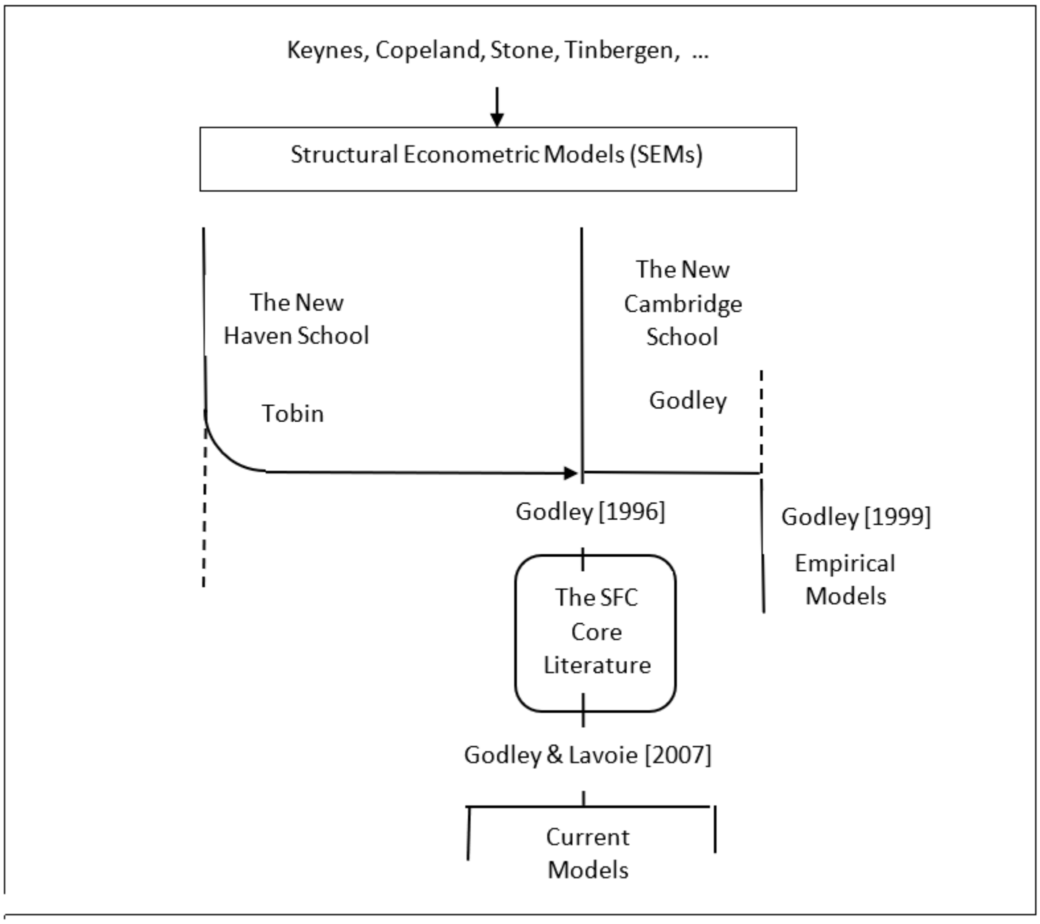

Figure 2.3.1: A Schematic of the Evolution of SFC Models

better name as it emphasizes their dual inheritance.

2.3.1 SFC Model Structure

This section describes the structure of SFC models and then shows how their construction relates to and supports the properties of the post-Keynesian alternative to the standard model listed in section 2.1.1 above (p.32).

There are two parts to an SFC model, a set of matrices and an accompanying set of equations. The matrices are essentially a presentational and organizational device, a visual aid to identifying what needs to be modelled and how things relate to each other. The real meaning of the model is captured in the equations.

2.3.1.1 SFC Models: The Matrices

Figure 2.3.2 is a schematic view of the matrices and how they interrelate.

The matrices are of two types — the flow matrices (the transactions matrix, the flow of funds matrix, the non-financial assets matrix and the revaluation matrix) and the stock matrices (the balance sheet). Each matrix consists of a set of rows and columns; the rows capture the assets or commodities being modelled (e.g. currency, government bonds, equities, consumption goods, labour services) and the columns represent sectors of the economy. The entries in the matrix represent flows (or stocks) of the asset or commodity for that sector in the time period.

Together, the matrices form a network: the sectoral balances of the transaction matrix are transferred to the flow of funds which shows how the balances change stock values; these stock value changes are the link between the opening balance sheet and the closing balance sheet. Other changes to stock values arise from

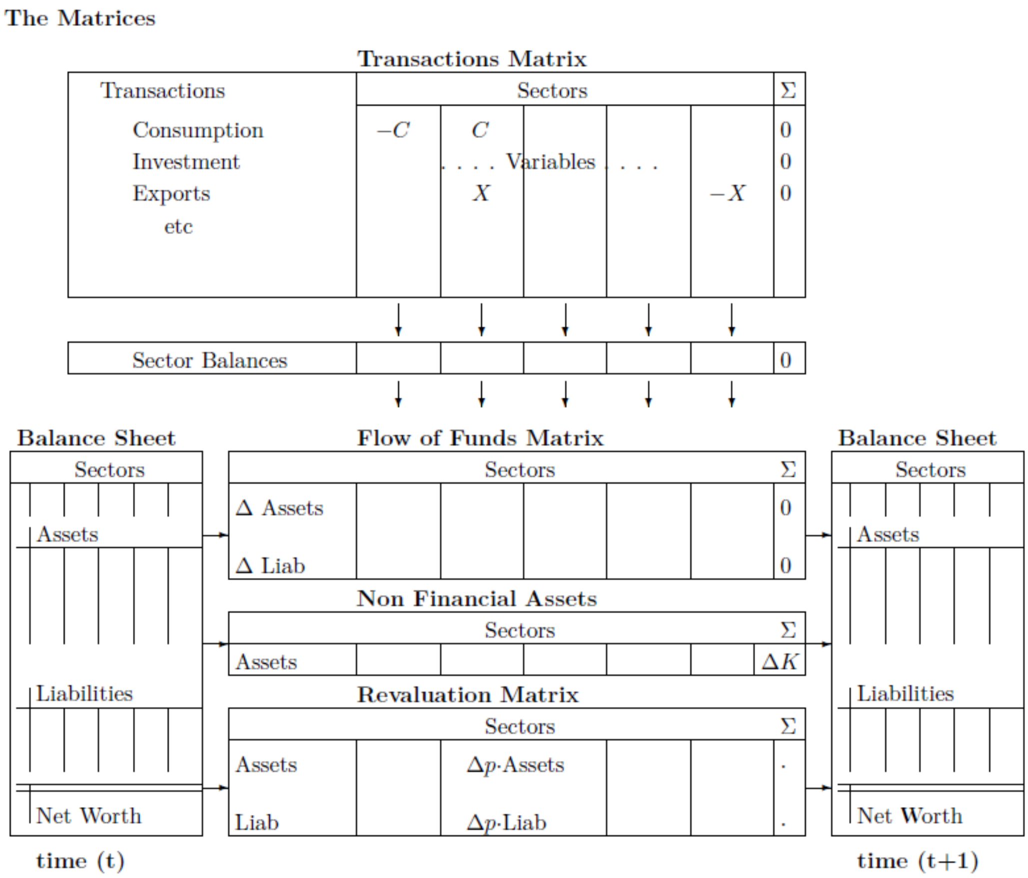

Figure 2.3.2: The Matrices of an SFC model and their Interrelationships

asset price changes in the revaluation matrix and acquisition of non-financial assets.

The transactions matrix shown at the top of figure 2.3.2; it is a flow matrix and will typically contain an income/expenditure model of the parts of the economy under study. Each row represents a value flow, and the entries in the cells capture the flows between sectors which may be expressed in terms of the parameters and variables of the model. The row totals in the Σ column are zero, which is one aspect of the rigorous accounting — everything comes from somewhere and goes somewhere, nothing is lost or gained. Godley & Cripps (1983) have likened this to a "law of conservation of energy for economics" (p. 18). The column totals of the transactions matrix are the sector balances. In a short period model, where there are no changes in stocks, these entries will also be zero; in general, however, there will be non-zero balances for some sectors indicating surpluses and deficits. These balances represent accumulation and decumulation of financial assets by the sectors.

These balances are reconciled in the flow of funds matrix which is represented by the second row of downarrows in figure 2.3.2. The flow of funds matrix specifies how the surpluses and deficits in the transactions flows are allocated to financial assets and liabilities. A surplus for one sector may lead to an increase in certain financial assets or a decrease in liabilities or a combination. The rows of the flow of funds matrix also sum to zero, since any transfer of assets from one sector must be exactly matched by a transfer to other sectors. This is another manifestation of the rigorous accounting. The horizontal arrows in figure 2.3.2 to the left and right of the flow of funds matrix represent the updating of stocks. The value of assets and liabilities in the balance sheet at time (t) are modified by the changes in stocks during the period in the flow of funds to yield their new value in the balance sheet at time ($t+1$). It is this relationship between the value of stocks in the previous and current time periods that makes the models inherently dynamic.

The next matrix shows net changes to non-financial assets (inventories and fixed capital); changes in non-financial assets will arise from investment expenditure in the transactions matrix. These will update the balance sheets in the same way as the flow of funds. Note, however, that the row sums in this matrix are not zero, non-financial assets have no counter-party liability in the way that financial assets do.

Finally, there is the revaluation matrix which captures changes to balance sheet values resulting from price changes. These are not transactions, they are capital gains and losses from holding assets and liabilities. The stock-flow relationships are depicted by the connections from the balance sheet at time (t) through the three flow matrices in the lower part of figure 2.3.2 to the balance sheet at time ($t+1$). It is this process of flows updating stocks and stocks determining new flows that provides the stock-flow consistency and also the temporal dynamics of the models.

The balance sheets capture the stocks, and they are also represented by sectoral matrices; the entries are the financial and non-financial assets and the liabilities of each sector at a specific point in time. The difference between total assets and liabilities for each sector is the net worth at that time point. The stock matrices at each time point are connected by the flow matrices which capture changes during the time period between time points, so historical time is an essential part of the models. Time may be continuous or discrete, there are examples of both in the literature, either can be appropriate depending on the application — for empirical models where historical data tend to be monthly, quarterly or annual, discrete models are more common. For analytical models, where empirical data is not involved, continuous time may be more suitable.

The surplus of the private sector can be taken as an example to illustrate how flows update stocks. The private sector surplus (or deficit) is $S - I$ where S is saving and I is investment. $S - I$ is the change in financial assets of the private sector in the period which is allocated through changes in stocks in the flow of funds matrix. The value of I is the change in non-financial assets which is allocated through changes in stocks in the non-financial assets matrix. S is the total change in assets, financial and non-financial, and is the change in net worth (net of revaluation effects).

2.3.1.2 SFC Models: The Equations

The matrices are transformed into an economic model by the accompanying set of equations. Tobin expresses it thus (Tobin 1982, p.175),

> In the format of these tables, a column represents a sector's balance sheet (stocks) or sources and uses of funds (flows). A row distributes the stock or flow of an asset over the supplying and demanding sectors. The task of theory and estimation is to bring the columns to life by functions relating sectoral portfolio and saving decisions to relevant variables, and to bring the rows to life as a set of simultaneous market-clearing equations.

The equations are expressed in terms of the model parameters and variables which may be endogenous (current or lagged) or exogenous. Model closure for a model with n endogenous variables requires $n - 1$ independent equations, since in a closed system the nth equation will be redundant, being implied by the other $n - 1$. The equations are of two types — accounting identities and behavioural equations. The accounting identities arise from the structure of the model — they capture row totals (which sum to zero for consistency) and the column totals (the sector budget constraints). In general, the number of accounting identities will not be sufficient to solve the model, and further equations capturing additional relationships between model variables will be required. This process of completing the model is called model 'closure'. The term 'behavioural equations' is generally used to describe these extra equations since they capture relationships between variables that depend on assumptions about the behaviour of the various sectors of the economy. In principle, the same model structure could generate different closures depending on the behavioural assumptions made, but in practice the main usage of SFC models reflects post-Keynesian assumptions[13].

2.3.1.3 SFC Models: Key Characteristics

Having introduced the main components of the SFC model, the manner in which its various aspects relate to the macroeconomic alternative to the standard model, listed on page 32 above will be discussed here.

The Sectors The sectors of the model represent the institutions of the economy (firms banks governments, etc). This is a fundamental point, the 'standard model' is built on individual behaviour, the alternative model is based on *institutions*. From Godley (1996, p.3) "It is a matter of

[13] Dos Santos (2005) gives an example of four different closures of an SFC model based on different assumptions in the style of Davidson, Minsky, Tobin and Godley.

ascertainable fact that the real world is characterised by a huge and complex structure of interdependent institutions such as governments, firms, banks and households. I do not accept that these institutions are 'veils' with nothing more to do than passively sponsor or facilitate the optimising aspirations of individual agents."

Accounting Consistency This serves to ensure the overall coherence of the model but also has a *dynamic* purpose. One of the key features of the accounting models listed on page 3 above was "(e) accounting identities (not the equilibrium concept) as determinants of model outcomes in response to shocks in the environment or in policy" Bezemer (2009, p.679). In Minsky's Financial Instability Hypothesis (Minsky 1986), it is the need to balance cash flows with contactual commitments that is the source of instability. Nikiforos & Zezza (2017, p.6) specify four main consistency principles of SFC macroeconomic modelling which arise from the rigorous accounting framework: (1) *Flow consistency*, "every monetary flow comes from somewhere and goes somewhere, there are no black holes" (Godley 1996, p.7) (2) *Stock consistency*, the financial liabilities of one agent or sector are the financial assets of some other agent or sector (3) *Stock-flow consistency*, every flow implies the change in one or more stocks. As a result, the end-of-period stocks are obtained by cumulating the relevant flows and taking into account possible capital gains. (4) *Quadruple-entry accounting*, in a single organization we have double-entry account reflecting origins and destinations of transactions but in a multi-sector model, four entries are required since each pair of transactions in one sector triggers a balancing pair in another sector.

For example, when a household purchases a product from a firm, the expenditure of the household may be balanced by a decrease in at least one of its assets (or increase in a liability), and at the same time an increase in the revenues of the firm and an increase in at least one of its assets. Quadruple-entry bookkeeping was introduced by Copeland (1949) and is now the fundamental accounting system underlying the international System of National Accounts (OECD 2008). This framework is presented in the quadruple-entry matrix format which was later to be adopted by Godley & Lavoie (2007c), although some SFC authors (e.g. Zezza & Dos Santos (2004), Taylor (2004b)) also use a Social Accounting Matrix (SAM) format (Pyatt & Round 1977) as developed by Stone at the Cambridge Growth Project (Barker 2003).

The Flow of Funds Godley (1996, p.5) emphasizes the *empirical* aspect of the flow of funds, "I start from the real world as described in (...) the National Income Blue Book which shows, for single years, a comprehensive matrix describing flows of funds in the British economy", but it also supports the *dynamics* of the models by showing how flows change stock values.

The Stock-Flow Relationship This is the main source of the *dynamics* of the model. Transaction flows in each period are conditional upon opening stock values. Closing stocks in each period are determined from opening stocks and current flows. This sets up an intrinsic dynamic in the models. "The increment in (...) stock, during a period, is the difference between what is held at the end and what was held at the beginning, and the beginning stock is carried over from the past. The demand-supply equation can only be used in a recursive manner to determine a sequence; it cannot be used directly to determine a price, as Walras and Marshall have used it" (Hicks 1989).

Time The Stock-Flow relationship and the Flow of Funds impose a time sequence on the model which allows representation of processes in *Historical Time* under conditions of *Uncertainty*. "Investment, production and distribution all take time and are all activities which have to be undertaken under conditions of uncertainty" (Godley 1996, p. 4)

Real and Financial Integration is achieved by several model features, inclusion of a financial sector allows the capture of financial processes "One role of the financial system will be to provide the finance required for investment in fixed and working capital (in advance of sales taking place) if production and distribution are to proceed (...) And it will also provide residual "buffer" finance for fluctuating inventories as short term expectations are falsified" (Godley 1996, p. 4).

This list has related some of the structural features of SFC models to the macroeconomic characteristics of the alternative to the standard model described on page 32, but compliance with the alternative model cannot be guaranteed by the characteristics of the modelling approach, although it is enabled. The rest depends on choices made by the modeller for example the inclusion of Portfolio Allocation with a Variety of Assets and Rates of Return, one of the cardinal points of Tobin's programme (p.45). Characteristics like imperfect competition and increasing returns, which were cited as essential features of Godley's alternative to the standard model on page 32 are not enforced by the SFC model itself, but are features of the way post-Keynesian

SFC models are closed.

2.3.2 Origins and History of SFC Models

Figure 2.3.1 implies that the origins of the New Haven and the New Cambridge models arise from a class of models called SEMs, a label that has variously been taken to represent Structural Economic Models, or Simultaneous Equation Models, but were often just referred to as Keynesian models. These are generally large multi-equation models and will be explained in section 2.3.2.4. The schematic shows them as derived from the work of Keynes, Copeland, Stone, Tinbergen and others. These economists could be said to have supplied the building blocks of the models — Keynes, the theory; Copeland, the Flow of Funds accounts; Stone, the National Income accounts; Tinbergen, econometric models and so on. There are many prerequisite components to SEMs and to SFCs, each of which is described separately below.

Fair (2012) offers a perspective on fifty years of post-war macro model building in which he identifies two distinct phases — 'macro 1', mainly based on large simultaneous-equation econometric models (the SEMs), and 'macro 2', dating from the late 1970s, following the Lucas Critique (Lucas 1976) and also Sims' critique. The 'Lucas Critique' was aimed at the use of econometric methods based on historical data. Lucas was critical of the use of large-scale macro-econometric models to evaluate policy impacts when the empirical correlations that they were built on were themselves sensitive to the same policy changes. He asserted that only models based on theory could account for shifting policy environments and that the only way forward was to derive models from explicit microfoundations; these models generally take the form of DSGE[14] models. The Lucas Critique was followed by Sims (1980), in which he questioned the basis of the identification restrictions typically imposed in structural time series models. The variables in such models are a mixture of current and lagged values; to ensure that the equation is 'identified', certain variables are chosen to be exogenous, and/or restrictions are placed on the current values; Sims argued that many of these restrictions were purely arbitrary. His solution was to estimate complete systems in an atheoretic way using vector autoregressions (VARs) where all variables are endogenous and estimated only in terms of their own lagged values and the lagged values of the other variables in the system, no current values, hence avoiding the identification problem. These eventually evolved into the Cointegration VAR approach (Johansen 1995) to be deployed in chapter 6, and will be described in section 3.1.4.

The next sections briefly describe the 'building blocks' and some background on SEMs. Nothing further will be said about DSGE models, and the VECMs will be described more fully in chapter 3.

2.3.2.1 National Income Accounts

National income accounts are a vital source of empirical data for SFC models, so their development during the first half of the twentieth century is an important part of the SFC history. Tily gives a historical account of the early developments, especially highlighting Keynes' contributions (Tily 2009). He starts with the pioneering contributions made at the start of the 20th century by Alfred Flux, Arthur Bowley and Josiah Stamp, and later by Colin Clark. The debates between these men mark the emergence of National Accounts as a serious

[14]Dynamic Stochastic General Equilibrium

discipline. Their work was supported by the earlier theoretical contributions of Alfred Marshall, and by practical developments, in particular the instigation of a Census of Production in 1907. Things moved further forward during Keynes' time at the Treasury during World War II, when he realized that planning a national economy needed accurate national accounting. Keynes commissioned James Meade and Richard Stone to create estimates of National Income and Expenditure (Meade & Stone 1941). Stone received the Nobel Prize in Economics in 1984 for his work on national and international accounting (Stone 1984). The United Nations introduced international guidelines in 1947 to promote better international comparisons of economic indicators. By agreeing on the definition of different monetary transactions, such as what counts as investment by businesses, national accounts figures became more comparable between countries. The International Monetary Fund published the first balance of payments manual in 1948. The Simplified System of National Accounts was first published in 1951 under Richard Stone's direction to aid in the adoption of national accounting systems. The latest version is OECD (2008). The standard for accounting for international transactions and balance of payments data is the IMF's Balance of Payments Manual now in its sixth edition (IMF 2009).

2.3.2.2 The Flow of Funds Accounts

The second major building block of the SFC approach was the development of the *Flow of Funds* accounts. Morris Copeland studied money flows and is often credited with being the father of the flow of funds accounts for the United States (Federal Reserve Bureau Z.1 Release). He wanted to find answers to fundamental economic questions such as "when total purchases of our national product increase, where does the money come from to finance them?" and "when purchases of our national product decline, what becomes of the money that is not spent?" (Copeland 1949). He laid the foundation for an economic approach able to integrate real and financial flows of the economy. The flow of funds provides a dynamic picture of the economy that complements the static picture of the National Income and Product Accounts.

2.3.2.3 The Social Accounting Matrix

Richard Stone's second contribution to SFC modelling, after National income accounts, was the Social Accounting Matrix (SAM). It is a matrix modelling method that is designed to show the interactions between sectors of the economy (Stone & Brown 1962) and was a product of the Cambridge Growth Project at the Cambridge DAE. Many authors developing SFC models use SAMs as the structure (Taylor 2004b, Papadimitriou *et al.* 2013), as an alternative to the double-entry transaction matrix described above, which seems to have originated with the Tobin models (Backus *et al.* 1980).

2.3.2.4 Structural Econometric Models

This section discusses the simultaneous equation econometric models of the early postwar period which were the precursors of the SFC models, as depicted in the top part of figure 2.3.1. These were large models, often with hundreds of equations which, according to Wren-Lewis (2016), came to be called 'Structural Econometric Models (SEMs)' or sometimes just 'Keynesian models' to contrast them with the single equation models being developed at the University of Chicago in the context of monetarism under Milton Friedman:

> He believed in a monocausal influence from changes in the stock of money to both nominal and real GDP. Accordingly in empirical studies a single equation approach was used in which changes in GDP followed, with appropriate lags, from changes in the money stock. The need for any structural modeling and with it the possibility of an endogenous dynamic of the macro economy was denied (Hillinger 2008, p.6).

The first modern econometric model of a national economy was constructed by Tinbergen who, along with Ragnar Frisch is considered one of the founders of modern econometrics, for which they were jointly awarded the first Nobel prize in economics in 1969. In 1936 Tinbergen produced a model of the Netherlands economy, from which he subsequently built a similar model of the US economy for the League of Nations in 1939 (Tinbergen 1939) and later also for the UK economy. Keynes was initially not very supportive of this work and wrote a rather disparaging review of Tinbergen's model (Keynes 1939), but the commonly accepted idea that he was opposed to the use of econometrics was later countered by Richard Stone (Pesaran & Harcourt 2000). After World War II, Tinbergen became director of the Central Planning Bureau of the Netherlands and there established the methodology that formed the basis of most post-war econometric modelling. Tinbergen's principal aim in this period was to provide inputs to economic policy decisions for which he constructed a dynamic simultaneous equation model along Keynesian lines, incorporating the policy variables of interest. This set the pattern for the postwar tradition of Keynesian model building and significantly influenced the work of other research groups. SEMs were developed by prominent research groups like the

Cowles Commission, the Department of Applied Economics at Cambridge, the National Institute of Economic and Social Research (NIESR) in the UK, the National Bureau of Economic Research (NBER) in the US, as well as public institutions and central banks; Ormerod (1979) gives a snapshot of the state of the art of macroeconomic modelling at the time.

The Cowles Commission had been founded in Colorado Springs in 1932 by Alfred Cowles, a businessman and economist. The Commission moved to the University of Chicago in 1939 but major ideological differences with the Chicago school in the 1950s led to it moving in 1955 to Yale University where it became the Cowles Foundation, James Tobin was later a director; see Christ (1994) for an account of its early history. Lawrence Klein was a very significant figure in postwar Keynesian model building; he had joined the Cowles Commission in 1944 and built a model of the US economy to correctly predict, against the prevailing expectation, that there would be an economic upturn rather than a depression due to increasing consumer demand from returning servicemen (Klein 1950).

It was also at this time, and partly at Keynes' behest that the Department of Applied Economics (DAE) at Cambridge University was founded (discussed earlier in section 2.1.2), and made significant contributions in model development, including the Cambridge Growth project (Barker 2003).

Early success of these models was tempered by their failure to deal adequately with the stagflation that followed the oil price shocks of the 1970s. The entire approach came under attack in 1976 by the 'Lucas critique' and Sims' critique referred to above, when mainstream macro modelling shifted from 'macro 1' to 'macro 2' in the terminology of Fair (2012). Despite being out of fashion, some pockets of structural macro-modelling persisted, Tobin's group continued at the Cowles Commission now renamed the Cowles Foundation. The strand in figure 2.3.1 labelled 'the Godley models' evolved from the modelling work at the DAE in Cambridge. The combination of these two strands could be termed 'the Tobin-Godley synthesis'[15].

2.3.2.5 The Tobin-Godley Synthesis

Comparing two publications from the early 1980s gives a view of how the Tobin and the Godley tradition differed at the time and how they subsequently merged. The first is Backus *et al.* (1980) which is a fully developed model in the tradition of the New Haven school, it exhibits most of the features of the later SFC models — a tableau presentation, five economic sectors, integration of the financial and real economy and full consistency of stocks and flows. The second is a presentation at a Cambridge conference on Keynesian economics where Godley was leading a session on 'Management of Real National Income and Expenditure' (Godley 1983), in which he sets out a succession of models in the style of the 'New Cambridge' school. Both emphasized stock-flow relationships in their own way; the Tobin paper focused on portfolio analysis and how the interaction of monetary policy and rates of return on financial assets impacted income and expenditure in the real economy. The Godley paper emphasized fiscal policy and how the expenditure of the government, operating through the multiplier, and the demand for financial assets of the private sector captured in the wealth-income norm impacted national income and expenditure. In

[15]The synthesis refers to the fact that the two came together in terms of the way the models were structured and particularly Godley's incorporation of Tobin's portfolio theory, not any convergence in their macroeconomics. The fact that they employed different behavioural assumptions in their model closures is mentioned on page 91.

Godley's model, monetary policy was passive by assuming interest rates to be held constant.

Over the next decade, these two approaches were to merge, or at least, the Godley/CEPG approach would absorb most of the features of the Tobin models in what might be termed a 'Tobin-Godley Synthesis', although that's not a label in widespread use. Tobin's programme was an ambitious attempt to move macroeconomic modelling in a new realist empirical direction, based on the national income and product accounts (NIPA) and the flow of funds accounts (FoF), incorporating both financial-real and stock-flow integration, however this was also the time of Monetarism and the 'New Classical Counter Revolution' (Wren-Lewis 2016) with its call for microfoundations, representative agents and rational expectations. Tobin responded to some of these issues in his Nobel lecture referred to on page 44, but the economic estabishment for the most part did not take up his challenge. Wynne Godley and the New Cambridge group did, however, and that forms the second part of the Tobin-Godley synthesis.

Godley explains that shortly after that, "around 1984 James Tobin spent a pleasant week in Cambridge (...) during which he instructed us in asset allocation, particularly Backus *et al.* (1980) which thenceforth was incorporated into our work" (Godley & Lavoie 2007c, P.xxxviii) and from this merger, the modern style of SFC modelling emerged.

This is the Tobin-Godley synthesis, the whole economy models from the CEPG embedded into Tobin's framework with its portfolio allocation and flow of funds[16]. This synthesis can be seen in the whole economy models published

[16]In Godley (1996) which is the first published example of this synthesis, he states "I shall instead adopt the methodology pioneered by James Tobin" (p.3), so he attributes the methodology entirely to Tobin.

by Godley in the late 1980s and early 1990s (e.g. Godley & Zezza (1989)), maturing into the series of models discussed in the next section described as 'the SFC core'. They incorporated virtually the whole of Tobin's methodology, with one significant difference — they employed post-Keynesian closures rather than the more 'neo-classical Keynesian' assumptions of the New Haven school.

2.3.3 An Overview of Published SFC models

Previous sections have discussed the structure of SFC models (section 2.3.1) and their history (section 2.3.2); this section reviews a selection of the publications in the SFC literature since the 'Tobin-Godley synthesis' under two separate headings. In the next section, a collection of publications from the period following Godley's 1996 paper up to the publication of *Monetary Economics* (Godley & Lavoie 2007c), is presented as the *SFC Core*; the reason for this classification, which has been devised specifically as part of this review, is that these papers are foundational, they demonstrate the maturity of the Tobin-Godley method and exploit its advantages by applying it to a range of macroeconomic theory questions but they also provide a base for other authors to create their own models following the Godley pattern — firstly, extolling the virtues of the modelling method, secondly, challenging the mainstream 'standard model' and thirdly presenting the post-Keynesian alternative. These publications extend the SFC method into open economy economics, monetary economics (endogenous money, the monetary circuit), Fiscal and Monetary policy, growth models and inflation.

The second group of publications reviewed are the *Strategic Analysis* series from the *Levy Economic Institute of Bard College* produced with the aid of the

Levy model, an SFC model originally developed by Godley for his seminal 1999 paper *Seven Unsustainable Processes*. The model has, in the intervening years, been maintained and updated by Levy Institute researchers. The reasons for selecting this group are twofold: firstly they demonstrate how the approach can usefully be deployed to explore various medium-term economic trajectories under different assumptions, bearing in mind that these analyses gave regular and cogent warnings about the imbalances and instability in the US economy in the pre-crisis period. But perhaps the more interesting feature of these publications is their method of analysis. They represent the thread in figure 2.3.1 labelled the *Empirical Models* starting with Godley's 1999 paper. These publications are discussed in section 2.3.3.2.

Combined, these two groups represent a strategically important subset of the SFC literature, but it is nevertheless an incomplete selection from what is now a large and rapidly growing genre. However, a comprehensive survey would be a diversion from the main objective, and there already exist excellent literature surveys (Caverzasi & Godin 2014, Nikiforos & Zezza 2017) which also cover the more recent post-crisis publications.

2.3.3.1 The SFC Core

It was suggested earlier that Godley's 1996 paper (Godley 1996) marked the consummation of the Tobin-Godley synthesis, being the first to contain a fully developed SFC model with all the features discussed in the previous section; and that it was followed by a set of publications that applied post-Keynesian assumptions and the SFC methodological approach to some of the key macroeconomic issues — open economy macroeconomics, fiscal and monetary policy, inflation, growth and the business cycle, banking and endogenous money — culminating in Godley & Lavoie (2007c) which is the authoritative text on the subject. Taken together, they form a base or core which collectively defines the method at the same time as expounding the alternative macroeconomics. This is the thread in the central part of figure 2.3.1. This core group is discussed in this section where they are divided into groups by subject area as shown in table 2.3.1.

The 1996 paper followed a pattern that was to become familiar — firstly to present the advantages of the methodology, secondly, to challenge the standard model and thirdly, to present the post-Keynesian alternative; "I am going to present a greatly simplified, but within its limitations, realistic, model of how a modern monetary economy may work" (Godley 1996, p.3). The principal deficiency of the standard model that he concentrates on in this paper is its (lack of) treatment of money "mainstream macroeconomics postulates in its standard model that macroeconomic outcomes are all determined by relative prices established in Walrasian markets (. . .) But as is now well kncwn, there is no use for money in the Walrasian world even though, paradoxically, "money" is a logical necessity if the model is to be solved" (p. 2).. These twin themes – SFC models as both a vehicle for the post-Keynesian alternative and a practical means to challenge the standard model — were taken up by other authors in the SFC literature of this period,

Taylor (2004a) uses an SFC model 'with full stock-flow accounting respected' to demonstrate that the balance of payments equation in the Mundell-Fleming model is not independent and cannot set the exchange rate;

Godley & Shaikh (2002) use an SFC model to identify an important inconsistency in the 'standard macroeconomic model' in its treatment of the distribution of income. "And when this seemingly small discrepancy is corrected, without any change in all of the other assumptions, many of the model's characteristic results diappear" (p. 1);

Lavoie (2001) uses an SFC model to clarify issues surrounding the debates within the post-Keynesian school concerning endogenous money, "Godley's method and work have substantial repercussions on post-Keyesian monetary theory because they provide formal means to assess the legitimacy of the claims made by this theory" (p.2).

What these papers are showing is that results formerly derived under a partial equilibrium analysis can be shown to be incomplete or inconsistent when analysed in a fully comprehensive, integrated macroeconomic accounting system. Examples of the SFC model as a vehicle for post-Keynesian macroeconomics are listed in table 2.3.1. These publications could all be considered part of the core SFC literature; the table associates each with the main macroeconomic subject area to which it contributes. Naturally, there is considerable overlap, each paper may cover more than one topic but for simplicity only its main contribution is listed, the purpose being to show how a comprehensive framework for a macroeconomic alternative to the 'standard model' has been built up step by step.

The first group in table 2.3.1 are mainly concerned with establishing the methodology. Besides the 1996 paper there is also Godley (1997) which re-emphasizes the three main themes — affirming the SFC methodological approach, mounting a critique of the standard model followed by a presentation of an SFC model of the post-Keynesian alternative. The methodological characteristics

Subject Area	Publications
The framework model in a closed economy	Godley (1996), Godley (1997)
Open economy macroeconomics	Godley (1999b), Godley & Lavoie (2003), Godley & Lavoie (2005), Godley & Lavoie (2007a)
The three balances and stock-flow norms	Godley & Izurieta (2004)
The banking system, endogenous money and the monetary circuit	Godley (1999c), Lavoie (2001), Lavoie & Godley (2003)
Fiscal and monetary policy	Godley & Lavoie (2007b)
Growth theory	Lavoie & Godley (2001), Zezza (2003)
Inflation	Godley (2004), Godley & Lavoie (2006)

Table 2.3.1: Foundation Publications in the SFC Literature

highlighted are the rigorous accounting, the integration of the real and the monetary economies and one further important feature of fully consistent stock-flow models — that they are amenable to quantitative solution by computer simulation "the first objective of the study is to supplement the narrative method used perforce by Keynes and his followers before the computer age" (p. 2). However the benefits of simulated solutions doesn't diminish the need for *empirical* studies "nothing, it is maintained, can be known about the real world unless it is actually studied empirically, hence no greater claim is made for the model presented here than that it is an elementary schema laying out a rigorous space within which empirical macro-economics can proceed " (p. 4).

Having affirmed the methodological features of the SFC modelling approach, it then proceeds to criticize 'the standard model' on three counts: first, the concept of an exogenous money stock; second, the axiomatic assumption that prices send all the signals that govern action, even in the presence of rigidities, imperfections and asymmetries in information flows and that expectations are invariably expectations about prices; and third, the standard model has no satisfactory way of handling real time. These are then contrasted with the theoretical assumptions of the SFC model: the role of money and the banking system "when decisions by households and firms are taken under conditions of uncertainty, and when production, distribution and investment all take time" (p. 2); decisions by households, firms and banks are mainly based, not on price but on quantity signals which often take the form of realized stocks of wealth or inventories; expectations concern, not just prices but such diverse things as sales, income and wealth; historical time is intrinsic because of the stock-flow relationship. Together these constitute "a realistic, if simplified, characterisation of the institutional framework within which all modern capitalist economies operate" (p. 4).

The second group in table 2.3.1 extends the basic framework into open economy models. The first, Godley (1999b), explores the properties of three simple models of two interdependent economies under varying assumptions. Again, the SFC framework is being exploited here to investigate theories of the exchange rate that have previously been pursued under 'partial equilibrium' assumptions, "No individual part of what follows is new. However these ideas have never before, so far as I know, been put together in the form of a single, dynamic model which can be simulated as a set of processes occurring in real time" (p. 1). Most theories postulate that exchange rates are determined by actual and expected interest rates and inflation. This paper argues that these factors may determine the *demand* for internationally traded assets, no theory of exchange rate determination is complete unless it also takes into account the *supply* of assets, and this is achieved by modelling domestic and foreign transaction flows in an integrated framework. The second paper in this group, Godley & Lavoie (2003), is a revised version of the first. Godley & Lavoie (2005) also builds on the same earlier models, using a model of an open economy under a regime of fixed exchange rates, with no private international capital flows, and uses this to show that reductions or increases in foreign exchange reserves, as a result of foreign exchange interventions by the central bank to keep the exchange rate fixed, have no effect on the money supply, in direct contradiction to a claim found in many textbooks. In other words, foreign exchange interventions by central banks are 'automatically' sterilized. In Godley & Lavoie (2007a), a similar model is extended to include three countries and two currencies, two of the countries share a currency, so the insights are applicable to the Eurozone. The main conclusion is that, if all three countries operate independent fiscal policies, the system will work under a floating currency regime, but only so long as the European central bank is prepared to modify the structure of its assets by accumulating an ever rising proportion of bills issued by the 'weak' euro country.

The third group of models deal with overall macroeconomic balances; (Godley & Izurieta 2004) does not use an SFC model per se, but pursues its argument by reference to historical national accounting data from the US and UK using the three balances analysis. It is an example of reasoning in the Kaldorian way, starting from stylised facts revealed by the data; it then deploys ratio analysis to provide insights into the sustainability of imbalances and the limits of some flows especially net lending to the private sector.

The fourth group deal with the banking system, endogenous money and the monetary circuit. Godley (1999c) integrates the theory of money and credit into the Keynesian theory of income determination with assets allocated according to Tobinesque principles. One conclusion of the paper is that there is no such thing as a supply of money distinct from the money which agents wish to hold. Lavoie (2001) provides further examples while Lavoie & Godley (2003) further outlines the post-Keynesian approach to banking, marking a break with the neoclassical 'loanable funds model'. It sets out the relationship between the banking sector and the central bank and captures Moore's theory of endogenous money in an SFC model.

The fifth group deal with fiscal and monetary policy; Godley & Lavoie (2007b) introduces the fiscal stance and its relation to the growth rate and the rate of interest. It argues that fiscal policy on its own could achieve both full employment and a target rate of inflation.

The sixth group deal with growth theory; Lavoie & Godley (2001) is the first treatment of growth models in a SFC framework. The model "extends Kaldor's 1966 model (Kaldor 1966) by assuming that firms obtain finance by borrowing from banks as well as by issuing equities. It includes an account of households' portfolio behavior as in Tobin (1969), where the proportion of wealth held in the form of money balances and equities depends on their relative rates of return. It also includes an investment function, which makes the rate of growth of the economy largely endogenous" (p.103). Many of the SFC growth models are Kaleckian, the distinguishing characteristic according to Godley and Lavoie being "in contrast with both Cambridge models of growth as in Robinson and Kaldor, and also with classical models of growth, rates of utilization in the long period are not constrained to their normal or standard levels" (p.103).

The final group deals with models of inflation. Godley (2004), re-states the methodological advantages of the SFC approach, accompanied by the usual critique of the standard model, then proceeds to develop a four sector SFC model with seven stocks and a model of inflation. Godley & Lavoie (2006) draws it all together, presenting a succinct statement of the whole approach with a model of inflation (although in a closed economy). In these models, Godley and Lavoie favour the 'conflict over income shares' view of inflation originally attributed to Rowthorn (1977).

The definitive work on the methodology of stock-flow modelling is Godley & Lavoie (2007c); it sets out a structure for the models and demonstrates how to construct and simulate them in a series of examples ranging from the most simple, culminating in models with a high degree of realism which set out a rigorous basis for the integration of Keynesian-Kaleckian macroeconomics as well as an advanced open economy model. This book has become the standard reference on SFC modelling; it is built upon the theoretical and methodological developments published in the sequence of papers published in the prior decade, referred to here as the SFC core literature.

The book has become the authoritative text on the SFC approach, fulfilling the role of an exposition of the post-Keyneian theory underlying the approach as well as a practical handbook for model builders. Lavoie has expressed the hope that the book and the approach might serve as a *lingua franca* not just for SFC modellers and post-Keynesians but more generally for the whole heterodox economics community "over the last decade, a number of post-Keynesians have adopted the use of matrices to better explore mesoeconomic relations. Inspired largely by the work of Wynne Godley and Lance Taylor, but also that of Eichner, I believe that such an approach constitutes an important new way of unifying all heterodox macroeconomics" (Lavoie 2014, p.264). Indeed, the authors themselves cite several commentators who point to the need for an integrating framework for post-Keynesian economics.

Luigi Pasinetti laments the fact that post-Keynesians have progressively failed to establish “a permanent winning paradigm” which he attributes partly to the “personal characters of the formidable economists who directly succeeded Keynes”. But Pasinetti also points to “a lack of theoretical cohesion in the various pieces which emerged from the Keynesian School which paid scant attention to the fundamentals on which an alternative, but coherent, paradigm could be built”. He suggests that “a satisfactory blueprint that could house, beneath one single roof, the development of the existing ideas along the Keynesian lines is still lacking” and that there is a need for “an account of what happens - as Keynes put it - in a ‘monetary production economy’, which is more complex than a pure exchange stationary economy, because it is intrinsically dynamic, continually affected by history, subject to changes both in scale and structure” (Pasinetti 2005) (quoted from Godley & Lavoie (2007c, p. 3)).

They also cite Geoff Harcourt who observes that the post-Keynesians have followed in the Marshallian/Keynesian tradion of partial equilibrium analysis, “. . . Post-Keynesian models (. . .) lay in spreadout pieces, with no account of how the system as a whole worked” what is needed is “a statement which characterizes how post-Keynesian theory can underlie the way in which an industrial capitalist economy works *as an organic whole*” (Harcourt 2001, p.277) (quoted from Godley & Lavoie (2007c, p. 3)).

The book’s aspiration is to provide a common approach around which could be assembled a unified, post-Keynesian alternative to the standard model in macroeconomics. In hindsight, it could be said that it hasn’t quite achieved that lofty ambition, but the uptake of the SFC modelling approach within the post-Keynesian community has been considerable.

2.3.3.2 The Levy Institute Strategic Analysis Series

The Levy Institute's Strategic Analysis series of publications (Levy Institute of Bard College 1999) are short policy notes appearing roughly twice a year on matters of economic policy that are of strategic importance for the US and world economy; in addition, since July 2013 there has also been a series of notes on the Greek economy based on the Levy Institute model of the Greek economy (LIMG) (Papadimitriou *et al.* 2013).

The reasons for studying this group of publications is as much for their method of analysis as for their content. Following the pattern set by Godley in the 1999 paper *'Seven Unsustainable Processes'*, they employ something like a 'Kaldorian' approach in the way that they start out from a presentation of 'stylised facts', that is, empirical observations of key economic data series over recent decades, which includes key ratios (flow ratios and stock-flow ratios), and use them firstly, to challenge current policy assumptions and secondly, as a guide in formulating an alternative narrative. In a second stage, the data are used to populate an SFC model of the US economy (and also of the world economy in the 1999 paper) which is then solved econometrically under several alternative sets of assumptions about policy and economic conditions over a five year time horizon to make projections of the medium-term trajectory of the economy. Godley was always at pains to emphasize that this is not 'forecasting' or attempts at 'fine-tuning' in response to short-term disturbances, but rather a way of identifying constraints on future growth paths.

In the 1999 paper, Godley took issue with the forecasts of the Congressional Budget Office (CBO) and the council of Economic Advisors to the President (EAP) in 1999 in which they predicted that the rate of economic growth that the US economy was experiencing at the time would continue more or less indefinitely. But that would lead to the following logical conclusion, "given unchanged fiscal policy and accepting the consensus forecast for growth in the rest of the world, continued expansion of the U.S. economy requires that private expenditure continues to rise relative to income" (p.5), which, from a consideration of stock-flow norms, is unsustainable. Godley argued, very much counter to the received wisdom, that, rather than having entered a new paradigm where 'growth had become structural'[17], the US economic growth was actually being driven by *Seven Unsustainable Processes* which he identified as,

1. the fall in private saving into ever deeper negative territory,
2. the rise in the flow of net lending to the private sector,
3. the rise in the growth rate of the real money stock,
4. the rise in asset prices at a rate that far exceeds the growth of profits (or of GDP),
5. the rise in the budget surplus,
6. the rise in the current account deficit,
7. the increase in the United States's net foreign indebtedness relative to GDP

These are the stylised facts which the paper addresses, each presented as plots of historical data from recent decades.

In the second stage, six alternative scenarios are analysed by means of an early

[17]a remark attributed to Edmund Phelps (Financial Times, August 9, 2000).

version of the Levy Institute SFC model and a model of the world economy. A brief description of the Levy SFC model is provided in the paper, a more recent update is provided in Zezza (2009). A notable feature is the estimation of the New Cambridge aggregate expenditure function in an ARDL model which finds a relation between aggregate private expenditure and private disposable income with added regressors for net lending to the private sector and asset prices (stock market and house prices). The world economy model is an early version of (Cripps & Izurieta 2014). The results of the analysis included projections of US and world GDP and private debt under each scenario, and a discussion of possible policy options to restore balance.

The paper became a model to be followed by others from the Levy Institute which are still being published to this day, for example, Godley & Izurieta (2001) updates the above analysis following the collapse of the dotcom bubble, but before the huge fiscal expansion of the 'war on terror'. It argues that further fiscal relaxation and measures that raise U.S. exports relative to imports are required. Godley (2003a) turns attention to the large and growing current account deficit of the US and its implications for the domestic economy. As in 1999, the growing imbalances, especially the mounting foreign debt were not considered to be a serious concern for policymakers who pointed to the relatively low cost of financing it. Based on a consideration of the three balances the report argues that the foreign deficit can not be isolated from its implications for the budget deficit. A number of solutions are identified, none of which seem politically feasible in the circumstances. Ultimately, a new world order is needed to replace the collapsed Bretton Woods agreement. Godley *et al.* (2004) again draws attention to the yawning budget and current account deficits and the highly indebted private sector; it makes no short-term forecast but warns that, unless the chronic trade deficit is addressed, sustainable growth in the medium term is not attainable. Papadimitriou *et al.* (2006a) warns about the deteriorating conditions in the housing market. Papadimitriou *et al.* (2006b) warns about the growing global imbalances. Godley *et al.* (2008) suggests that the stimulus planned to counter the global financial crisis will be insufficient and that what is required is a coordinated international effort to raise world demand as well as a willingness to tackle global imbalances.

In summary, the Levy Institute Strategic Analyses provide an example of the SFC methodology in practice, using all the elements of the approach discussed in previous sections, namely, the use of empirical observations and stylised facts to raise questions and draw attention to theoretical issues, the use of flow ratios and stock-flow norms to identify imbalances, and the use of an SFC model to study trajectories for the economy under plausible alternative policy scenarios.

2.3.4 SFC Models in Use

Having discussed the structure of SFC models in section 2.3.1, their history in section 2.3.2 and examples of published models in section 2.3.3, it is now time to draw out some summary points about applying them in practice. One issue is the method of solution, to be discussed in the next section.

2.3.4.1 SFC Models: Methods of Solution

The foregoing discussion has identified various ways of using SFC models, the two discussed in section 2.3.3 were the models of the 'SFC core' which were *theoretical* models, mainly using computational simulations, aimed at challenging aspects of the mainstream standard model or advancing understanding of the post-Keynesian alternative; in contrast, the Levy Institute models were *empirical* models aimed at narrowing down available policy choices. This suggests one way of classifying models according to how they are solved. Such a 'taxonomy' of current approaches to SFC modelling was proposed in Caverzasi & Godin (2014), in which they identify several modes of use of SFC models: "(i) theoretical models with a discursive solution, (ii) theoretical models solved via simulation and (iii) fully empirical models" (p. 2).

Type (i) models with a discursive solution are examples of the use of the SFC framework as a thinking tool and a format for presentation. The stocks and flows are set out in matrices as a way of showing consistency and completeness, but there is no attempt to close the model. An illustrative example is given in a paper by Botta *et al.* (2015) in which the authors develop a model of the shadow banking system. The model has a very large balance sheet and rather complex flows. To formulate a full set of equations would be an extremely complex undertaking and to attempt a solution would probably be unrealistic given the data requirements. However, the use of the SFC framework clarifies the exposition and helps in reasoning about consistency and completeness.

The overwhelming majority of SFC models currently published would fit into type (ii), models with a simulated solution. Given that realistic models of the economy can lead to large sets of equations that do not lend themselves to analytic solution, the option of numerical simulation of solutions extends the power and scope of the method. Such an approach can also cope with non-linear systems. Equations are derived from accounting identities and behavioural assumptions as described in section 2.3.1. Parameter values and values for exogenous variables and the initial state may based on generally accepted values from the literature or values may be assumed. The system may be simulated when there is an independent equation for each endogenous variable, values for the exogenous variables, the initial state and values for all equation parameters. The system is usually started from a steady or stationary state, then its response to applied shocks to parameters or exogenous variables can be studied.

Type (iii) fully empirical models use econometric methods to estimate parameter values of the equations. Once the stocks and flows of interest have been identified and the accounting structure established, the model is 'closed' by proposing behavioural relationships between the variables of the model based on assumptions from economic theory. The parameters of these equations are estimated econometrically based on empirical data at which point the model can be used for out-of-sample forecasting.

This thesis proposes a fourth method based on the 'data first' approach to be discussed in section 2.4, in which a model of the data is constructed in an 'atheoretic' way using a Johansen cointegrating VAR model (Johansen 1995) as a data model whose cointegrating relations are used to interpret the theory models being investigated. This approach is applied in chapter 6 on a three sector SFC model.

This results in a classification of model usage like that in table 2.3.2.

Type of Model	Method of Solution	Method of Parameterization
Discursive	None	Not Required
Theoretical	Analytical	Parameter values are assigned by adopting values from other models or studies or widely accepted values from the literature
	Computational	Stylised Facts Calibration: Parameter values are chosen to match a particular dataset Estimation: Parameter values are estimated using econometric techniques
Empirical	Estimation	Parameters estimated econometrically but may be mutable

Table 2.3.2: SFC Models: Method of Solution and Parameterization

2.4 The Empirical Estimation Approach

Chapter 6 will present a cointegrating VAR (Vector Auto Regression) of a three sector SFC model. This section will briefly survey the relevant literature leading to the emergence of the cointegrating VAR model.

Banerjee *et al.* (1996, p.111) offers the following high level statement of the problems of econometric modelling, “most empirical econometric studies are an attempt to interpret and summarize data in the light of both statistical theory and economic analysis” (p.111); marrying these three elements, economic data, statistical analysis and economic theory is confounded by three major obstacles, firstly the complex nature of the economy, which derives “from the transacting behaviour of large numbers of separate yet interdependent agents, all striving to achieve their disparate, self-selected (and generally opposed) objectives, given their initial endowments, the available information about an uncertain future and the constraints imposed by the environment in which they operate. Since the plans of such agents are not necessarily mutually consistent, outcomes generally differ from plans and certain magnitudes must adjust to reconcile the various conflicting aims, in turn inducing different future behaviour. It is an inherently dynamic, stochastic, multidimensional, interdependent, non-linear and evolving entity of considerable complexity, the overall functioning only partly understood"; secondly, "the data are usually imprecise, samples are small and are not derived from controlled experimentation, and the observations relate to the final outcomes not the original plans and expectations"; and finally, "economic theory often provides only a first approximation to how such systems might function in idealized states".

These difficulties were in evidence in the crisis in large 'Keynesian' model-building in the 1970s (discussed in Section 2.3.2) leading to the critiques from Lucas (Lucas 1976) and Sims (Sims 1980), among others. These critiques were a challenge to the particular modelling approaches involved, large simultaneous equation systems (SEMs), that had performed quite well during the relatively stable post-war years but which broke down in the turbulence of the 1970s stagflation, following the breakdown of the Bretton Woods agreement and the oil price shocks. This failure of the modelling approach was widely interpreted as a failure of Keynesian macroeconomics itself, but in hindsight, it is apparent that it was actually econometrics that was in crisis. Several leading econometric authors at the time published their own critiques of econometric practice in response to that of Lucas (Hendry 1980, Sims 1980, Leamer 1983). Lucas had argued that "there is no reason to believe that the 'structure' of the decision rules (or economic relations) would remain invariant under a policy intervention

[..] What was required was a separation of the parameters of the policy rule from those of the economic model. Only when these parameters could be identified separately given the knowledge of the joint probability distribution of the variables (both policy and non-policy variables), would it be possible to carry out an econometric analysis of alternative policy options" (Geweke *et al.* 2006, p.15). There were two main areas of response to this — revisiting the 'identification' problem and and investigation of the general phenomenon of 'structural breaks'.

The identification problem had been recognised right from the earliest work on econometric models. In the case of simultaneous equation models the identification problem concerns whether there exists a sufficient number of *a priori* restrictions to be able to determine the structural parameters of the model from the reduced form parameters, the reduced form being a transformed version of the original structural model where each endogenous variable is expressed only in terms of exogenous (or possibly lagged endogenous) variables and constants. Sims critique was that the restrictions that were used to achieve identification in large models were often entirely arbitrary. He asserted that economic theory was, in general, not capable of providing identification of structural models and clearly determining which variables are exogenous and which endogenous; his proposal was to formulate the problem as a VAR model where all variables are endogenous.

Structural breaks can originate from many sources, not just changes in policy. The Chow test had been developed in 1960, but new work emerged on testing for structural change, detection of breaks, modelling of break processes by means of piece-wise linear or non-linear dynamic models, generating a considerable literature of which comprehensive surveys have periodically been compiled (Stock 1994, Clements & Hendry 2006).

A third issue that had plagued modelling of time series data was non-stationarity; that the presence of unit roots could lead to spurious regression had been known almost from the beginning (Yule 1926). This problem hampered the development of time series econometrics for a generation, "It is scarcely an exaggeration to say that statisticians of the writer's generation were so frightened by Udny Yule's famous paper on "Nonsense Correlations" that we came to regard economic time series as so much dynamite, to be handled at all times with extreme caution and not to be handled at all if one could avoid it " (Geary 1949, p.149). It was the development of the concept of *cointegration*, first introduced by Granger in 1986 and more formally developed in Engle & Granger (1987) that broke the impasse, and dynamic econometrics evolved very rapidly after that (Hendry 1995, Johansen 1988, Johansen & Juselius 1992, Phillips 1991). The definitive work on combining the concepts of cointegration with the VAR model is Johansen (1995) which is further developed in (Juselius 2006); this is the approach to be employed in chapter 6.

Parallel to this work on dynamic econometrics was methodological progress for its use. One in particular is the LSE methodology, also known as the Hendry methodology or 'General-to-Specific modelling' which has been evolving for some time (Gilbert 1986, Hendry 1995). It views econometric models as 'reductions' of some unknown 'data generating process' (DGP). The starting point is a complex DGP which is then reduced by a series of restrictions which are tested at each stage. The objective is to arrive at a sound model of the data and then apply the notion of 'encompassing' where rival hypotheses deduced from theory are tested to see whether they are contained within the data model. The ideas behind the Hendry methodology have been cast into a slightly different form which has been called the CVAR approach (cointegrated vector autoregression) by Hoover *et al.* (2008), Juselius (2010 2011), Moller (2008). Both the Hendry methodology and the CVAR approach have been described by those authors as examples of the 'data-first' strategy whereby pure models of the data are produced and then tested to see whether they 'encompass' or 'nest' both the DGP and the theory model under test.

> The cost is that we now need another level of modelling in addition to theory — a statistical model constructed in such a way that (a) theory has implications interpretable in its terms, and (b) data are described fully enough that its only residuals are identically independent random errors, that is, unsystematic noise. The payoff is that such a statistical model ... provides a firm basis for deductions about the implications for theory ... While we can never know for certain that our statistical model captures the data-generating process, we can often find compelling evidence when it does not...in other words there are no *sufficient* conditions but there are *necessary* conditions (Hoover *et al.* 2008, p.252).

Juselius (2018) argues that economic data are analyzed as short-run variations around moving longer-run equilibria. Longer-run forces are in turn divided into the forces that move the equilibria (pushing forces, which give rise to stochastic trends) and forces that correct deviations from equilibrium (pulling forces, which give rise to cointegrating relations). By modelling the data directly, the prospects for 'nesting' or 'encompassing' the DGP and relevant theory models is improved compared to approaches where 'a priori' restrictions are imposed on the data, which they call a 'theory-first' strategy (Hoover *et al.* 2008, Juselius 2006).

Naturally, these methodological innovations have not been greeted with universal acclaim. Lawson (2009) takes issue with many of the critical voices raised in the wake of the global financial crisis, not for their challenges to mainstream economics, but for their neglect of what he sees as the underlying problem, an over-reliance on formalistic modelling. His concern is that one group of models will just be substituted for another, both being based on the same methodological fallacies. The problem "is not so much the use of specific inappropriate models, but the emphasis on mathematical deductivist modelling *per se*. Such models can provide limited insight at best into the workings of the economy (or any other part of social reality). Indeed, I will suggest that the formalistic modelling endeavour mostly gets in the way of understanding" (Lawson 2009, p.760). He singles out as a specific target, Colander *et al.* (2009) which is just one of those challenges to mainstream economics over the failures relating to the global financial crisis and a call for greater 'realism' in economic models, citing the CVAR methodology as a possible improvement over current methods.

The main object of Lawson's challenge is "mathematical deductivist modelling", about which he has written extensively elsewhere (Fullbrook 1999, Lawson 1997 2003), and the concomitant "presuppositions of economic modellers that (i) empirical regularities of the sort required are ubiquitous, and (ii) social reality is constituted by sets of isolated atoms"(p.764). Perhaps those are the pre-suppositions of *some* modellers, but are the polar opposite of the view of the economy described by Hendry above (p.107) or those of Godley in section 2.1.1. Lawson contrasts those pre-suppositions with an alternative, "at all points in, and stages of development of, the financial system, we are faced not with an ubiquity of regular behavioural patterns underpinned by isolated systems of human atoms, but with the perpetual emergence of novelty, not least at the level of relational structures, underpinning transformed mechanisms and practices. This sort of continual emergence within a relationally structured, interconnected, totality in motion is seemingly the essence of any financial system within capitalism" (p.774). His 'totality in motion' sounds not unlike the view of the economy as a *complex adaptive system* put forward in chapter 3. His way forward is "not to attempt to mathematically model and perhaps thereby predict crises and such like, but to understand the ever emerging relational structures and mechanisms that render them more or less feasible or likely" (p.774), from which we conclude that, in his view, modelling does not contribute to that understanding.

Another earlier critique, which predates the CVAR methodology but addresses closely related topics, specifically, the Hendry methodology, VAR modelling and cointegration, is Darnell & Evans (1990), which, after setting out criteria for a scientific basis in empirical economics (a Popperian falsificationist view), proceeds to review traditional practice as well as the three topics against those criteria. They find that Hendry's 'General to Specific' modelling is open to charges of 'measurement without theory', "thus the 'inductively' based conclusions cannot be seen as making any significant contributions to our understanding of economic phenomena" (p.93). They are equally dismissive of the VAR approach "there are fundamental methodological objections to

VAR modelling: no theory, beyond the definition of variables, is utilized in the approach and an immediate consequence of this is that no behavioural economic theories are stated in falsifiable form — therefore the approach is no part of science. Moreover, any particular VAR representation is merely an inductively based conclusion and open therefore to all the standard charges of inductivism" (p. 128); cointegration is also simply dismissed as "measurement without theory" (p.142). Interestingly, they assert that the Hendry methodology and the VAR approach are to be rejected for their 'inductive nature' while Lawson, cited above, renders a similar verdict because of their 'mathematical deductivist' approach. Blattenberger & Kiefer (1992), in a review of Darnell & Evans (1990), conclude "…discussion is in order not only on the relative merits of the various approaches but also on the falsificationist perspective itself. Given the impossibility of real falsification, the authors' strict dichotomy between theoretical and atheoretical methods is somewhat overblown" (p.253).

There are various reasons why economists develop models; one is economic forecasting, but as the models in the 'SFC core' (section 2.3.3.1) demonstrate, another important one is to understand basic economic mechanisms and to probe theoretical questions. In the area of forecasting, it has often been the case that 'atheoretic' methods, from the early Box-Jenkins ARIMA models (Box & Jenkins 1978) to the Sims VAR models, have outperformed models with built-in theoretical assumptions, "the model that usually wins in forecasting competitions is the simple second order difference model, which is totally void of any economic content. Sophisticated economic models usually come last (see Clements & Hendry (1999), Hendry (2006))" (Juselius 2011, p.429). Atheoretic models won't, however, help with the second objective above of facilitating understanding of economic processes, except possibly when they make evident empirical regularities which can then stimulate new theoretical explanations, somewhat in the manner that Kaldor was attempting with his stylised facts (Kaldor 1957 1961).

This leaves the yet-to-be answered question of whether Lawson is right and modelling is futile (broadly supported by Darnell & Evans (1990)), or whether the 'data-first' strategy, by constructing pure data models, unconstrained by *a priori* assumptions, which can 'nest' or 'encompass' both the DGP and the theoretical model under test, offers a way forward as its proponents claim. The models of chapter 6 will use this CVAR approach to capture a three sector SFC model and test for the presence of partial adjustment processes in its dynamics, and hopefully add one further data point towards the resolution of that question.

2.5 Summary

This chapter has described the background and the context into which this research fits, in terms of the relevant extant literature, starting with a view of the macroeconomic theory, through the dynamic concepts of the flow and stock-flow ratios to a description of the SFC modelling approach itself. Finally, a brief account has been provided of the origins of the econometric approach to be applied in later chapters, specifically the CVAR methodology of Johansen and Juselius.

The macroeconomic background positioned Godley as a post-Keynesian and a Kaldorian; he was an *applied economist*, not an academic theorist. From Kaldor he got a commitment to an empirical grounding for economics, often taking the form of *stylised facts*. It was just such a stylised fact that gave rise to the *New Cambridge* hypothesis which informed much of his modelling and analysis right up to the global financial crisis. His characterisation of the neo-classical *standard model*, whose failings and inadequacies he would repeatedly reveal, was contrasted with a characterisation of a post-Keynesian alternative which captures what he thought a modern monetary economy was really like.

One aspect of his view of how an economy works, concerns fiscal and trade policy as captured in the *flow ratios*, and specifically their role in the dynamics of the economy. These flow ratios are *partial multipliers* and drivers of economic activity and hence, of the national income. The stimulus (or restraint) applied by the flow ratios is stabilised by the action of the *stock-flow norms*; the combined action of the ratios takes the form of a *partial adjustment process* causing the national income to converge to a stationary state, or a steady growth path.

Against this background, the SFC modelling approach was portrayed as providing a vehicle for both demonstrating the flaws in the standard model and disseminating the post-Keynesian alternative. The origins of the approach in the work of Tobin and the New Haven school and Godley and the New Cambridge school were recounted, and two distinct sets of published models were studied, the first has here been called the *SFC core*, the second set were a selection of the Strategic Analysis reports from the Levy Economic Institute. These two sets represent distinct modes of use of SFC models, those from the SFC core had the objective of exploring questions in post-Keynesian theory — open economy macroeconomics, growth theory, endogenous money, inflation —

through computational simulation. The second set represent a more *empirical* approach where some aspect of the current state of the economy was analysed by means of the flow ratios, the stock-flow norms and stylised facts to reveal imbalances or unsustainable conditions. The Levy model, an SFC model of the US economy, was used to trace out various scenarios for medium-term output, employment and growth under alternative assumptions about policy and the world economy. The pattern for this set of models were established by Godley's seminal 1999 paper *'Seven Unsustainable Processes'* which warned of the impending collapse of the dotcom bubble; subsequent reports repeatedly warned of growing imbalances in the pre-crisis period.

Finally, the chosen econometric method to be used for the empirical representation of the SFC models in later chapters was reviewed with reference to the published literature, starting from the crisis in the large econometric models of the 1970s signalled by the Lucas critique and the Sims critique. The responses to the failures highlighted by Lucas and Sims, particularly in relation to time series models revolved around the *identification* problem, *structural breaks* and the development of the theory of *cointegration*, culminating in the *Cointegrating VAR* which provides the means of building robust models of economic time series data which *nest* or *encompass* the data generating process (DGP) as well as any applicable theory models, an approach they call a *data-first strategy*, in contrast to a *theory-first strategy* in which data models are formulated with 'a priori' restrictions imposed by economic theory. The data-first approach has been commonly criticised for being, atheoretic, inductive, positivist, mathematical deductivist and measurement without theory, to cite just a small selection; the two critiques reviewed are representative of some of the views about the data-first approach that have been expressed in the literature.

Chapter 3

The Empirical Modelling Methodology and the Sources of Data

The chapter discusses how the research objectives stated in the preceding chapters will be carried out in the following ones. The first section discusses the methodological approach to be followed and the second section documents the sources of the empirical data to be used and how it has been downloaded and processed.

3.1 The Methodology

The introduction listed amongst the objectives of this research a test of the following view of how a modern economy functions, a view frequently expressed by Godley, see section 2.2.2 for example, 'the flow ratios act through the multiplier to determine income, constrained by stock-flow norms through the action of a partial adjustment process'. This could be called 'Godley's hypothesis'; the reason for the interest in this view is that, if it is even partially correct, it implies an important role for fiscal policy in the determination of output and employment. This can be compared with the prevailing mainstream view that expansionary fiscal policy leads to higher inflation rates and higher real interest rates in the long run, while it has no impact on real activity (referred to on page 28). This is the view that has been predominent for the last three decades; according to this view, post-crisis austerity is exactly the right policy. But the success of post-crisis austerity has been questioned by many economists, even those from the 'mainstream', a very small sample could include Krugman (2012), Wren-Lewis (2015), DeGrauwe & Ji (2013), Delong & Summers (2012), Holland & Portes (2012). If there is logical and empirical support for Godley's hypothesis, it would not just aid in understanding the workings of the economy, but also go some way to explain the long and slow recovery in the post-crisis period, as chapter 7 explains (p.379).

The approach taken in studying this hypothesis has three main elements: firstly, what could be called a *descriptive analysis* in which the time series properties of the flow ratios and the stock-flow ratios will be studied, secondly, a *logical* analysis in which the behaviour of the ratios will be studied through simulation, and thirdly an *econometric* analysis in which the time series of a three sector economy will be captured in VAR models to capture the action of partial adjustment processes. There is a strong empirical underpinning in all three stages. These separate types of analysis correspond quite closely to the individual chapters of the remaining part of the thesis. But first, it is necessary to fit the methodological apprroach into a framework of the methodological assumptions underlying it.

3.1.1 Methodological Assumptions

Godley's 'ontological assumptions' — his views about how the economy actually works — were discussed in chapter 2 (p.32). They include the existence of institutions, the role of uncertainty, the endogenous nature of money, the importance of stocks, the demand driven nature of the economy, the need for modelling in historical time and the need for a disequilibrium dynamics to understand economic outcomes. Those assumptions are broadly in line with those of the post-Keynesians, as discussed in section 2.1, and are accepted in full as foundations for this study, but are expressed in slightly different terms — those of *Complexity Economics*, as described earlier in chapter 1 (p.6).

Some particular aspects of the views Godley expressed about how economies actually work overlap with this Complexity Economics approach; for example, his view of economies as extremely complicated interdependent systems changing through historical time; the need for institutions which are 'heterogeneous agents' with diverse expectations and motivations; his disdain of the need for 'microfoundations' and his emphasis on "how whole economic systems function"; these were all amply described in chapter 2.

There is a further overlap between this Complexity Economics viewpoint and Hendry's 'three major obstacles' cited earlier (section 2.4), firstly, *the complex nature of the economy*, secondly, the data are usually imprecise, samples are small and are not derived from controlled experimentation, and the observations relate to the final outcomes not the original plans and expectations and thirdly, economic theory often provides only a first approximation to how such systems might function in idealized states. Hendry's ontology fits exactly into the complexity economics view, "it is an inherently dynamic, stochastic, multi-dimensional, interdependent, non-linear and evolving entity of considerable complexity, whose overall functioning is only partly understood" (Banerjee *et al.* 1996, p.111). Hendry's response to this economic complexity has been to devise a methodological approach that is robust in the face of these difficulties. The approach has been under continuous development since the early 1980s when it was known as the 'LSE methodology' (Gilbert 1986, Hendry 1995) but is now more commonly referred to as the *Hendry methodology.* It is an example of the 'data-first' approach discussed in section 2.4 (p.110), perhaps even the forerunner of that approach. A brief synopsis will be presented below, followed by a summary of the methodological implications for this research; the most complete and up-to-date reference on the approach is Hendry & Doornik (2014).

In the Hendry methodology, in keeping with the spirit of the data-first approach, the overall objective is to build a model of the data relevant to a particular problem which is interpretable in terms of the theory question under investigation. The economy is viewed as being so complex and multi-dimensional, that it is, in large part, unobservable directly[1]. The means we have of knowing anything about it is through the data that it generates, it can be viewed as

[1]This is not to say that *economic variables* or *economic data* are unobservable, but the economy itself,

> an inherently dynamic, stochastic, multidimensional, interdependent, non-linear and evolving entity of considerable complexity, whose overall functioning is only partly understood

as cited from Banerjee *et al.* (1996, p.111) in the previous paragraph (p.122); it's as if they are saying that the economy itself is transcendent, the only thing that can be observed directly is the data that it generates.

a *data generating process* (DGP). Analysis begins with the complete set of random variables relevant to the economy under investigation over a defined time span. Haavelmo (1944) asserts that the observations of economic data are drawn from a joint probability distribution of that set of random variables. The reluctance to use probabilistic models in economics prior to that was due to the fact that successive observations of economic variables could not be independent. Haavelmo argued that this was not necessary, "it is sufficient to assume that the whole set of, say n, observations may be considered as one observation of n variables (or a "sample point") following an n-dimensional joint probability law, the existence of which may be purely hypothetical" (p.iii). Hendry's DGP is the stream of observations from this underlying joint probability distribution, but it is unmanageably large and much of the data may be unmeasurable, so to derive a useable empirical model of the data involves a series of *reductions*, derived from the DGP through a series of 'information-preserving' transformations which are tested at each stage. The criterion for 'no loss of information' is the concepts of *nesting* and *encompassing*, introduced in section 2.4. All models in a reduction sequence are reductions from a common DGP, they are said to be nested in the DGP, but particular models may not be nested relative to one another. The concept of encompassing asks whether one model can explain the results of a rival model. A reduced model should be able to explain the results of a more general model from which it is derived, this is the condition for no loss of information in the reduction as a whole, so a valid reduction requires that a derived model should encompass the initial unrestricted model.

One important implication of the theory of reduction relates to the partial adjustment processes introduced in section 2.2.2. In a typology of dynamic processes, Hendry (1995, p.256) shows that a partial adjustment process is a reduction of an AD(1,1) model (autoregressive distributed lag, with one lag on each of the autoregressive and exogenous terms), as are the other common single equation dynamic processes, including the ECM (error correction model); so the AD(1,1) nests both the partial adjustment process and the ECM. Thus, the AD(1,1) could be considered a DGP for single-equation dynamic models; the AD(1,1) can be written,

$$y_t = \beta_0 + \beta_1 z_t + \beta_2 y_{t-1} + \beta_3 z_{t-1} + \epsilon_t \qquad \text{where } \epsilon_t \sim \mathrm{IN}[0, {\sigma_\epsilon}^2]$$

The partial adjustment process is a restriction on the AD(1,1) where it is assumed that $\beta_3 = 0$, that is, the lagged exogenous term is zero,

$$y_t = \beta_0 + \beta_1 z_t + \beta_2 y_{t-1} + \epsilon_t$$

which is of the same form as equation 2.4. The partial adjustment process will be taken up again in chapter 5.

3.1.2 Descriptive Analysis

By the term descriptive analysis is meant a study of the properties of the flow ratios and the stock-flow ratios as individual time series. The main properties of interest include whether they are stationary, trending, stable, volatile, etc and whether there are discontinuities that might form possible breakpoints in the series. Besides the properties of the time series in isolation, there is an interest in looking for cointegration between some series, notably the flow ratios and national income. The following sections will introduce the econometric concepts of stationarity, cointegration and Granger-causality which will be the main tools for assessing these properties. Historical values of these time series will be sourced from the US IMA (section 3.2)[2].

The first step in the analysis consists of visual inspection of the time series through plots of historical data to reveal the nature of the data, specifically the properties mentioned above — trending, stationarity, stability, volatility and trying to associate any discontinuities or break points with possible changes in the economic regime or policy.

The other two main properties of interest here are the *stationarity* of the stock-flow ratios, which is the principal criterion for whether a ratio qualifies to be considered a norm, and the *cointegration* between the flow ratios and the national income. If the flow ratios are to be shown to be 'drivers' of the national income, there is a presumption of 'causality' in the sense that the flow ratios could be used as predictors, with some time lag, of income. If two time series are cointegrated, there must be a 'Granger-causal' ordering in at least one direction (Engle & Granger 1987). Cointegration tests and Granger causality tests will be used to investigate these relationships.

3.1.2.1 Stationarity

The concept of time series stationarity is crucial to dynamic econometrics and clear expositions of the concept are to be found in any econometrics text (Gujarati & Porter 2009, Hendry 1995). Non-stationary series pose various problems for econometric analysis, in particular ordinary least squares regression

[2]US data has been preferred for reasons of quality and availability — Eurostat data is also of good quality and availability but the time series are quite short, dating only from the 1990s; nevertheless, it has been used for part of the logical analysis.

(OLS) becomes unreliable since the error term is often highly correlated and the t and F statistics are distorted leading to the risk of *spurious regression* (Yule 1926). For this reason, tests for stationarity will be a necessary part of the descriptive analysis for all time series.

The first distinction to be made is that between *trend stationary*, where the series is growing with a determinstic time trend, and *difference stationary* series which have a *stochastic* trend. The distinction between the two is illustrated by the following simple example,

$$x_t = x_{t-1} + \mu = x_0 + \mu t$$

and

$$y_t = y_{t-1} + \epsilon_t = y_0 + \sum_{s=1}^{t} \epsilon_s$$

where μ is a fixed constant and ϵ_t is a white noise process. x_t is trend stationary since it is represented by a deterministic trend μ whereas y_t is explained by its accumulated shocks (a stochastic trend) and is called difference stationary, since differencing yields $y_t - y_{t-1} = \epsilon_t$ which is a white noise process and therefore stationary.

The difference stationary series are further split into two types of stationarity — *covariance* stationarity and *strict* stationarity. It is covariance stationarity, also called weak stationarity, that is relevant here and that is what is meant henceforth by the term stationary; it requires that, if y_t is a time series, then $E(y_t) = \mu < \infty$, i.e. it has a constant finite mean, and $Cov_s(y_t) = \gamma(s)$ is finite and independent of t for all s where Cov_s is the covariance between y_t and y_{t-s} (the covariance must be independent of t but it may depend on s). In particular, if $s = 0$, Cov_s is the variance which must be finite and constant for all t.

Stock-flow norms, are relations between time-series such that, even though the constituent time series are usually non-stationary, the resulting ratio *is* stationary. Time series stationarity is proposed here to be the demarcation criterion for stock-flow norms. Any two time series can be combined to form a ratio, but to qualify as a norm, the ratio must form a stable series with a constant mean to which the ratio eventually returns after being deflected. To clarify, the investigations in subsequent chapters will be based on the following definitions; a *stock-flow ratio* is any time series formed from constituent time series for a stock and its corresponding flow. If the ratio is stationary, it will be considered to be a *stock-flow norm*, and the value assigned to the norm will be the mean of the series.

As stated by Godley & Cripps (1983), stock-flow norms are contingent on other structural properties prevailing in the economy at any given time; they may change with changes in policy, environmental conditions, the state of the international economy and many other 'exogenous' factors. It is beholden on the researcher, before appealing to a stock-flow norm, to demonstrate that the time series is stationary in the relevant time interval[3]. Standard econometric tests for stationarity to be employed in later chapters are described in section 3.1.2.3 below.

[3] The relevant time period depends on the context of the study. If the time period is in the future, some sort of continuity assumptions will be required. We are constantly reminded that the past may not be a reliable guide to the future, but it's about the only thing we have. To avoid getting into esoteric discussions of ergodicity etc, we could adopt Godley's pragmatism — he didn't do 'forecasting' but simulated various medium-term scenarios under differing explicitly stated assumptions. These often led to stock-flow ratios far from their historic 'norms'. This didn't mean that they couldn't happen, just that they seemed less likely; see Godley (1999c).

3.1.2.2 Cointegration

Another time series property that forms a stationary time series out of two (or more) non-stationary series is *cointegration*. The concept was introduced in section 2.4 above in the discussion of the econometric estimation approach. The theory of cointegrated time series is generally attributed to Granger (1981) and Engle & Granger (1987). It involves identifying linear combinations of time series of order $I(d)$ such that the resulting series has a lower order of integration; most commonly, two $I(1)$ series will combine to form an $I(0)$ or stationary series. The great benefit that cointegration brings is that it enables analysis of non-stationary time series while avoiding such issues as spurious regression; this is very significant for economics since most economic time series are non-stationary. It has been successfully coupled with the VAR approach (Sims 1980) to form the cointegration VAR methodology (Johansen 1995, Juselius 2006), henceforth referred to as the CVAR method; it underpins the modelling approach in chapter 6 and is introduced in section 3.1.4 below.

Besides its use in the models of chapter 6, cointegration methods will contribute to establishing the relationships between the flow ratios and national income in chapter 5, but has been discounted as a criterion for stock-flow ratios to qualify as norms for reasons discussed in section 3.1.2.2(b) below.

3.1.2.2(a) Granger Causality Tests

Granger tests will be used in section 5.1 to establish an ordering between the flow ratios and the national income. The approach to Granger testing is taken from Gujarati & Porter (2009, p.652), and is briefly summarised here.

Regression analysis establishes correlation between variables but this does not necessarily imply causation. However, where time series data are concerned, there is an additional consideration because time does not run backwards. If an event A happens before event B, it's *possible* that A is causing B, but it is *not possible* that B is causing A. This is the idea behind the Granger test, if previous values of time series A are helpful in predicting current values of time series B, we can say that A Granger-causes B, but this doesn't mean there is a cause and effect relationship between them. The approach can be illustrated by considering the following two regressions:

$$Y_t = \sum a_i X_{t-i} + \sum b_j Y_{t-j} + u_t$$

$$X_t = \sum c_i X_{t-i} + \sum d_j Y_{t-j} + v_t$$

The first equation says that Y is explained by past values of itself as well as past values of X. The second equation says the same for X. When these regressions are estimated, there are four separate cases to consider,

1. Unidirectional causality from X to Y: if the coefficients of the lagged X in the first equation are statistically significant, but those of the lagged Y in the second are not significant, then past values of X are helpful in explaining current values of Y, but past values of Y do not help in explaining X.

2. Unidirectional causality from Y to X: the converse situation to that described above. Past values of Y help in explaining current values of X, but past X do not explain Y.

3. Bilateral causality: both sets of coefficients are significant in both equations.

4. Independence: the coefficients of X in the first equation, and the coefficients of Y in the second are not significant.

The procedure for executing the test consists of the following steps:

1. Regress current values of Y on all lagged values of itself, but do not include X values as regressors. This is the restricted regression, the residual sum of squares of this regression is the RSS_R.
2. Rerun the regression but include all lagged values of X as regressors. The residual sum of squares of this regression is the unrestricted RSS_{UR}.
3. The null hypothesis is $H_0 : a_i = 0, i = 1, 2, ...n$, that is, lagged X terms do not belong in the regression.
4. To test this hypothesis, calculate the F statistic,

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)}$$

which follows the F distribution with m and $n-k$ degrees of freedom. Here, m is the number of lagged X terms and k is the number of parameters estimated in the unrestricted regression.

5. If the computed F value exceeds the critical F value at the chosen level of significance, reject the null hypothesis, in which case the lagged X terms belong in the regression, that is, X Granger-causes Y.

The procedure can be repeated in the other direction to check whether Y Granger-causes X. Note: the series in this test should be stationary, and the errors uncorrelated.

3.1.2.2(b) Cointegration and Stock-Flow Norms

Early versions of this investigation of stock-flow norms proposed cointegration of time series as the econometric basis, rather than time series stationarity, however, this was eventually revealed to be incorrect. Cointegrated time series are formed as *linear combinations* of their constituents whereas stock-flow norms are *ratios*. The possibility that, if two time series are cointegrated, their ratio might be stationary, or vice versa, ultimately proved not to be the case. If time series for a stock S_t and a flow F_t are cointegrated, then there is a linear combination that produces a new time series, $CR_t \equiv S_t - a \cdot F_t$ and CR_t is stationary, $CR_t = u_t$ where u_t is a white noise process, i.e. with a constant mean and variance and covariances independent of time t. From CR_t the ratio S_t/F_t can be formed, $S_t/F_t = a + u_t/F_t$. The term u_t/F_t is the ratio of a white noise process and a non-stationary time series which, in general, will be non-stationary, so S_t/F_t must be non-stationary. Since two non-stationary time series that are cointegrated, have a ratio S_t/F_t which is non-stationary, it might be concluded that cointegration between the stock and the flow is a condition for *non-stationarity* of their ratio.

An alternative approach to finding a link between cointegration of stocks and flows and stationarity of their ratios involved logarithms; if S_t/F_t is a stock-flow ratio, then its log is $log(S_t/F_t) = log(S_t) - log(F_t)$, which is a linear combination of $log(S_t)$ and $log(F_t)$. So if the logs of the stock and the flow are cointegrated, a new stationary time series $cr_t \equiv s_t - b \cdot f_t$ is formed, where lower-case letters denote log values. Since cr_t is stationary, $cr_t = v_t$ where v_t is a white noise process distinct from u_t. As before, the log of the ratio, $log(S_t/F_t) = s_t - f_t$ and from the cointegrating relation, $s_t - f_t = v_t + (b-1)f_t$. This will only be stationary if $b = 1$ and the right-hand side of the expression reduces to v_t. If $b \neq 1$, the right-hand side series is the sum of a stationary and a non-stationary process which will be non-stationary.

In both of the above cases, there is also the possibility of a time trend in the cointegrating relation, but this doesn't change the conclusion, since the question just changes to whether the resulting ratio is stationary about a deterministic time trend as opposed to whether it is mean-stationary.

3.1.2.3 The Unit Root Testing Methodology

In the descriptive analysis, two statistical tests for non-stationarity will be applied, the *Augmented Dickey-Fuller* (ADF) test (Dickey & Fuller 1981) and the *KPSS* test (Kwiatkowski *et al.* 1992). The ADF test has as its null hypothesis the presence of a unit root whereas the null hypothesis for the KPSS test is stationarity. These tests can advantageously be used in combination since the ADF test is known to be of low power and sometimes fails to reject the null hypothesis when it is false – "it lacks power to detect stationarity" (Gujarati & Porter 2009, p.759). The KPSS inverts the null hypothesis, i.e. the null is that the series is stationary against the alternative that it contains a unit root.

The procedure to be employed for ADF testing proceeds through a sequence, starting from the most general, assuming an intercept and trend in the time series then, depending on the outcome, progressively testing more resticted models. To test for a unit root in a time series y_t, the ADF procesure starts from following most general equation with an intercept and a trend,

$$\Delta y_t = \beta_1 + \beta_2 t + \pi y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + u_{1t} \tag{3.1}$$

where the lag length k can be determined by consideration of the particular time series or by recourse to information criteria. The test statistics for this case are,

Hypothesis	Test Statistic
$\pi = 0$	τ_τ
$\beta_1 = 0$ given $\pi = 0$	$\tau_{\alpha\tau}$
$\beta_2 = 0$ given $\pi = 0$	$\tau_{\beta\tau}$
$\beta_1 = \beta_2 = \pi = 0$	ϕ_2
$\beta_2 = \pi = 0$	ϕ_3

Table 3.1.1: Test Statistics for ADF test with intercept and trend

The next equation in the sequence applies the restriction $\beta_2 = 0$ resulting in a series with an intercept but no trend,

$$\Delta y_t = \beta_1 + \pi y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + u_{2t} \tag{3.2}$$

The test statistics for this case are,

Hypothesis	Test Statistic
$\pi = 0$	τ_μ
$\beta_1 = 0$ given $\pi = 0$	$\tau_{\alpha\mu}$
$\beta_1 = \pi = 0$	ϕ_1

Table 3.1.2: Test Statistics for ADF test with intercept no trend

Finally, the equation with no intercept or trend,

$$\Delta y_t = \pi y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + u_{3t} \tag{3.3}$$

The test statistics for this case are,

Hypothesis	Test Statistic
$\pi = 0$	τ

Table 3.1.3: Test Statistics for ADF test no intercept or trend

These tests are applied in sequence according to the logic in figure 3.1.1.

3.1.3 Logical Analysis

The logical analysis to be performed in chapter 5 involves performing computational simulations of the 'Godley hypothesis', that the flow ratios drive the economy through the multiplier constrained by stock-flow norms. A *complete multiplier* in the sense of Leite (2015) is developed which incorporates the stock-flow norms. Then, by applying 'shocks' to the 'drivers', ie. the flow ratios, the response of the system is computed and displayed in the form of time-plots of the transition to a new steady state.

3.1.4 Econometric Analysis

The approach to cointegration analysis to be followed here is the Johansen cointegrating VAR procedure (Johansen 1995, Juselius 2006), also with a very accessible guide in Juselius (2018). The procedure is implemented in the **R** environment for statistical computing R Core Team (2017) using the `vars` package described in Pfaff (2008a) which draws heavily from Lütkepohl (2006) which in turn rests upon Johansen & Juselius (1992), Johansen (1995).

Starting from a basic statement of a VAR model with K endogenous variables and p lags,

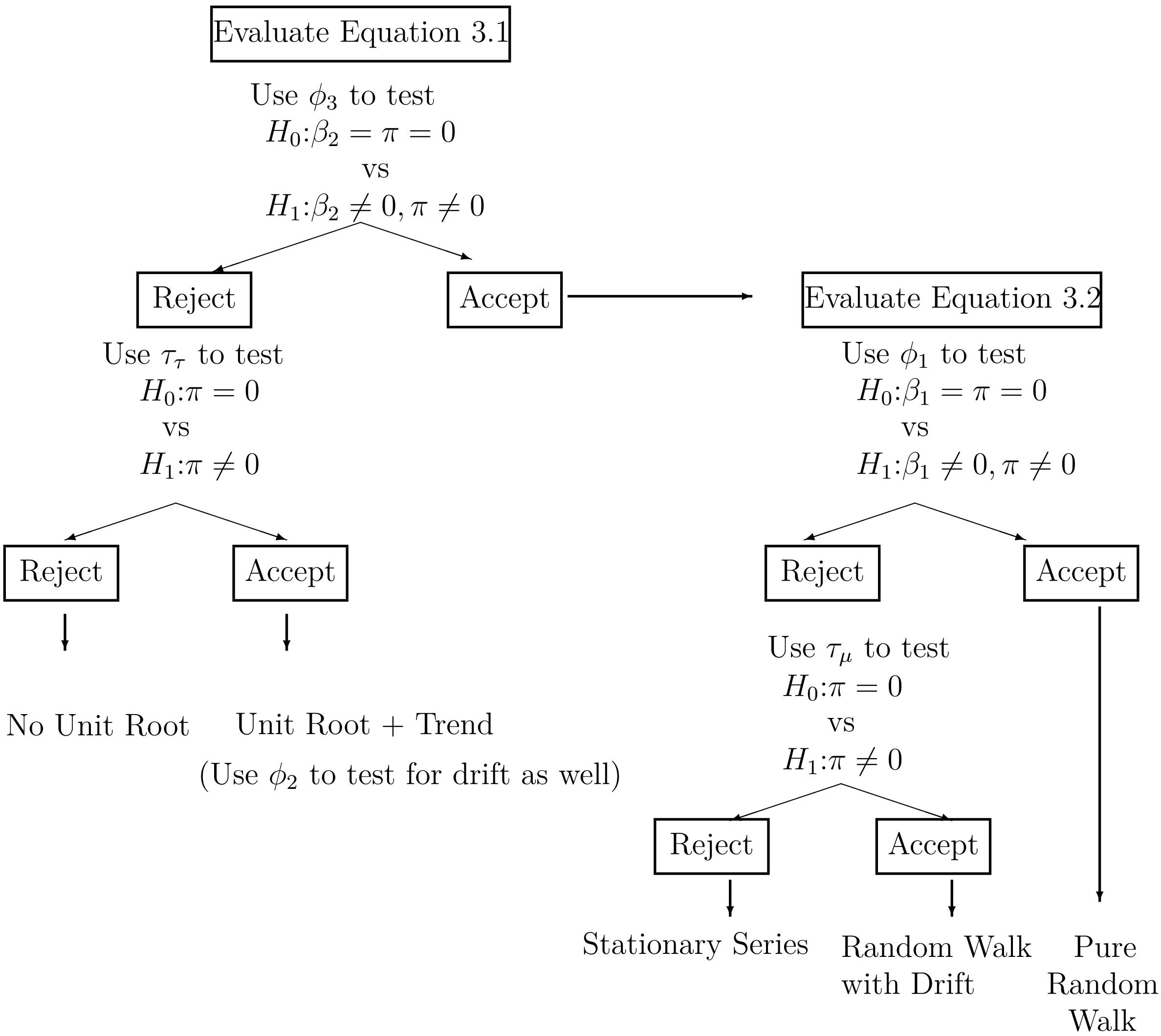

Figure 3.1.1: The sequence of tests involved in the ADF unit root test

$$\boldsymbol{y_t} = \boldsymbol{\Pi_1 y_{t-1}} + \ldots + \boldsymbol{\Pi_p y_{t-p}} + \boldsymbol{\mu} + \boldsymbol{\Phi D_t} + \boldsymbol{\epsilon_t} \tag{3.4}$$

where $\boldsymbol{y_t}$ is a $K \times 1$ vector for $t = 1 \ldots T$. The matrices Π_i, where $i = 1 \ldots p$ are $K \times K$ coefficient matrices of the lagged endogenous variables, $\boldsymbol{\mu}$ is a $K \times 1$ vector of constants and $\boldsymbol{D_t}$ is a vector of non-stochastic terms such as seasonal dummies or a deterministic trend. The $K \times 1$ error term $\boldsymbol{\epsilon_t}$ is a vector of independent and identically distributed 'white-noise' error terms with mean zero and time invariant positive definite covariance matrix $\boldsymbol{\Sigma} = E(\boldsymbol{\epsilon_t \epsilon_t'})$, meaning that $\boldsymbol{\epsilon_t} \sim \mathcal{N}(0, \boldsymbol{\Sigma})$.

The basic VAR of equation 3.4 can be formed into a vector error correcting model (VECM) by differencing in two ways; in the first form, the levels term is in $\boldsymbol{y_{t-p}}$ while in the second it is in $\boldsymbol{y_{t-1}}$. The first form is,

$$\boldsymbol{\Delta y_t} = \boldsymbol{\Gamma_1 \Delta y_{t-1}} + \ldots + \boldsymbol{\Gamma_{p-1} \Delta y_{t-p+1}} + \boldsymbol{\Pi y_{t-p}} + \boldsymbol{\mu} + \boldsymbol{\Phi D_t} + \boldsymbol{\epsilon_t} \tag{3.5}$$

where

$$\boldsymbol{\Gamma_i} = -(\boldsymbol{I} - \boldsymbol{\Pi_1} - \boldsymbol{\ldots} - \boldsymbol{\Pi_i}), \quad \text{for} \quad i = 1, \ldots p-1,$$

$$\boldsymbol{\Pi} = -(\boldsymbol{I} - \boldsymbol{\Pi_1} - \boldsymbol{\ldots} - \boldsymbol{\Pi_p})$$

and $\boldsymbol{I}$ is the $K \times K$ identity matrix. As can be seen from the new coefficient matrices $\boldsymbol{\Gamma_i}$ and $\boldsymbol{\Pi}$, these terms contain the cumulative long-run impacts and hence this form of the VECM is called the *long-run* form. For comparison, the other form is

$$\boldsymbol{\Delta y_t} = \boldsymbol{\Gamma_1 \Delta y_{t-1}} + \ldots + \boldsymbol{\Gamma_{p-1} \Delta y_{t-p+1}} + \boldsymbol{\Pi y_{t-1}} + \boldsymbol{\mu} + \boldsymbol{\Phi D_t} + \boldsymbol{\epsilon_t}$$

where

$$\boldsymbol{\Gamma_i} = -(\boldsymbol{\Pi_{i+1} + \ldots + \Pi_p}), \quad \text{for} \quad i = 1, \ldots p-1,$$

$$\boldsymbol{\Pi} = -(\boldsymbol{I - \Pi_1 - \ldots - \Pi_p})$$

The $\boldsymbol{\Pi}$ matrix is the same in both cases, but the $\boldsymbol{\Gamma_i}$ matrices are different in that they now measure transitory effects, so this is called the *transitory* form.

Since the components of $\boldsymbol{y_t}$ will be I(1), the left-hand side of the VECM will be stationary after differencing once; likewise the lagged terms in $\boldsymbol{\Delta y_t}$, so for the equation to balance, the error-correction term, $\boldsymbol{\Pi y_{t-p}}$ (in the long-run form) must be stationary too. To determine the conditions on $\boldsymbol{\Pi}$ for stationarity of this term, there are three cases to consider,

1. $rk(\boldsymbol{\Pi}) = K$
2. $rk(\boldsymbol{\Pi}) = 0$
3. $0 < rk(\boldsymbol{\Pi}) < K$

where $rk()$ is the rank of the matrix. In the first case, all linearly independent combinations must be stationary, so the model reduces to a standard VAR model in levels of $\boldsymbol{y_t}$. In the second case, $\boldsymbol{\Pi}$ is the null matrix and there are no linear combinations to make $\boldsymbol{\Pi y_t}$ stationary so this model reduces to a VAR model in first differences. The interesting case is the third, since the matrix does not have full rank, two $K \times r$ matrices $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ exist such that $\boldsymbol{\Pi = \alpha\beta'}$. Hence $\boldsymbol{\alpha\beta' y_{t-p}}$ is stationary and therefore the product $\boldsymbol{\beta' y_{t-p}}$ is stationary.

The r linearly independent columns of $\boldsymbol{\beta}$ are the cointegrating vectors and the rank of $\boldsymbol{\Pi}$ is the cointegrating rank of the system $\boldsymbol{y_t}$, that is, each column of $\boldsymbol{\beta}$ represents one long-run relationship between the individual series of $\boldsymbol{y_t}$. The elements of $\boldsymbol{\alpha}$ determine the speed of adjustment to the long-run equilibrium, it is referred to as the *loading* or *adjustment* matrix, analogous to the speed of adjustment factor ϕ in the partial adjustment process in equation 5.4. The elements of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ can only be determined in relative terms so are presented by normalizing one element of $\boldsymbol{\beta}$ to one. A method for determining these cointegration vectors using maximum likelihood estimators is developed in Johansen (1995).

3.1.4.1 The Six Step Procedure for VAR Analysis

Application of these principles to the estimation of VARs/VECMs leads to a procedure having the following steps:

Step 1: Data Transformation; following a descriptive analysis of the time series, it may be necessary to transform the data, for example eliminating outliers, taking logs, de-meaning, de-trending etc.

Step 2: Carry out unit root tests on the individual time series to determine their order of integration. For the reasons outlined in section 3.1.2.1 (p.125), both ADF and KPSS tests will be applied.

Step 3: Determine where any breakpoints in the series lie; these will identify 'sub-series' each of which could be the subject of a separate VECM estimation. It has been found that the resulting VECM is extremely sensitive to the choice of breakpoints. Initially, the method of determining breakpoints relies on a visual inspection of time series plots, combined with exploratory VECM estimations. Each of the VECMs estimated in chapter 6 will be subjected to a 'sensitivity analysis' of the choice of lags and breakpoints.

Step 4: Determine the lag order of each VECM. This is determined by the R function `VARselect()` from the R package `vars` (Pfaff 2008a). There is a choice of the information criteria to be used, including the Akaike Information criterion (AIC), the Hannan-Quinn (HQ), The Schwartz criterion (SC) and the 'forecast prediction error' (FPE). Generally, the Hannan-Quinn criterion is preferred.

Step 5: Estimate the VECM and determine the order of cointegration from the rank of the $\mathbf{\Pi}$ matrix. The VECM estimation is performed by the function `ca.jo()` also from the `vars` package (Pfaff 2008a). The function offers a choice of tests between the *maximal eigenvalue* or *trace* statistics (Johansen 1995) to determine the order of cointegration; the form of the VECM can be the 'long run' where the levels of $\boldsymbol{y_t}$ have lag $t-p$ as described above in section 3.1.2.2 (p.128), or the 'transitory' form where the levels of $\boldsymbol{y_t}$ have lag $t-1$ (Pfaff 2008a, p.79); the long run form is being used here. Other options include a choice of constant, linear trend and seasonal dummy variables.

Step 6: Determine the cointegrating relations. This is performed by the function `cajorls()` in R package `urca` (Pfaff 2008a), once the order of cointegration has been determined from the tests of the maximal eigenvalue or trace statistics in the previous step. The function returns the OLS regressions of a restricted VECM and the normalised cointegrating relationships. The vectors $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, the constituents of the $\mathbf{\Pi}$ matrix are calculated.

3.2 The Data Sources

The empirical data used in this study is all 'secondary data', i.e. it has been sourced from public open access repositories, there has been no independent data gathering undertaken. There are three main sources for the data,

IMA: The "Integrated Macroeconomic Accounts of the United States" (IMA) is an official publication which integrates balance sheet data, flow of funds data with income and expenditure data from the National Income and Product Accounts (NIPA). It is a joint activity between the US Federal Reserve Board and the US Bureau of Economic Analysis (BEA), which is part of the US Department of Commerce. The Federal Reserve Board has been publishing the "Financial Accounts of the United States" as the Z.1 data release since 1945. The Z.1 includes balance sheet information, flow of funds and integrated macroeconomic account data. The BEA is responsible for publication of the NIPA accounts and much other economic data. The integrated macroeconomic accounts (IMA) were developed as part of an inter-agency effort to further harmonize the NIPA from the BEA with the financial accounts in the Z.1 release from the FRB. Historically, the Z.1 release had focussed more on the flow of funds while the NIPA emphasized production, income and expenditure; the IMA brings the two together. Besides harmonisation, an important objective was to bring the accounts into line with international standards, specifically, the System of National Accounts (SNA 1993) which is the accepted international standard for national income accounting, sponsored by the

United Nations, the OECD, the IMF and other organisations. SNA1993 has now been upgraded to SNA2008 which is the current standard. The IMAs are largely in accordance with the SNA, but there are differences, particularly with respect to the way sectors are defined.

Data frequency for the Z.1 release is annual from the end of 1945 and quarterly beginning in 1952Q1, and the IMA has been retro-assembled to the same frequency. The time series in this study are quarterly and run from 1960Q1 to 2016Q4.

The *Flow of Funds* accounts were mainly instigated by Morris Copeland who made substantial contributions to national income accounting in the 1930s and 1940s (Copeland 1949 1952). They link successive balance sheets by showing changes in the assets and liabilities of each sector from one period to the next and how these have served as *sources* and *uses of funds*. Detailed statements for each account show how net capital has shifted to or from various sectors, allowing for a granular look at movement of funds within the economy, as well as into and out of it. The relationship between the balance sheet and the flow of funds is the relationship between *stocks* and *flows*, the balance sheet shows the assets and liabilities of each sector of the economy at a point in time, the flow of funds show changes to assets and liabilities of each sector during a period, and hence link two balance sheets together.

Eurostat: Some Eurostat data is used in section 5.7 to compare the settings of the flow ratios for various European economies. Eurostat is an official agency of the European Commission, it was originally established in 1953. Its main responsibilities are to provide statistical information to the institutions of the European Union (EU) and to promote the harmonisation of statistical methods across its member states and candidates for accession as well as EFTA countries.

The data are taken from the non-financial Annual Sector Accounts (ASA) which are an international format of accounts by sector following the standard defined in the European System of Accounts (ESA 2010) which is a European adaptation of SNA2008. Specific information on the data structures and the download process are provided in section 3.2.2.

Each of these sources is further described in the sections below detailing the data sourced and how it has been treated. In addition, there are some miscellaneous data items that are described in section 3.2.3.

3.2.1 The Integrated Macroeconomic Accounts of the United States

Most of the data used in chapters 4 and 6 have come from the IMA. The IMA consists of a large number of time series dating back as far as 1945. Each time series has a structured code which serves to uniquely identify it but also gives specific information about it. The structure of the codes is explained in section 3.2.1.1. The website of the Federal Reserve Board makes these time series available for download. The download process is presented in section 3.2.1.2

3.2.1.1 The Structure of the Codes

The structure of the code is illustrated by the following example[4],

```
FA 15 30611 0 5 .  Q
```

The code consists of six fields:

FA The first field consists of two characters which give the nature of the time series, see table 3.2.1.

Prefix	Meaning	Derivation
FA	Flow, seasonally adjusted annual rate (SAAR)	(FU + FS) * 4
FC	Change in unadjusted level	FL - FL[t-1]
FG	Growth rate, seasonally adjusted (SA)	FA / LA[t-1] *100
FI	Index	FL / 1000
FL	Level, not seasonally adjusted (NSA)	FL[t-1] + FU + FR + FV
FR	Revaluation	FL - FL[t-1] - FU - FV
FS	Seasonal Factor	FA / 4 - FU
FU	Flow, not seasonally adjusted (NSA)	FL - FL[t-1] - FR - FV or FA/4 - FS
FV	Other changes in volume	FL - FL[t-1] - FU - FR
LA	Level, seasonally adjusted (SA)	LA[t-1] + FA/4 + FR + FV
LM	Level, market value, not seasonally adjusted (NSA)	LM[t-1] + FU + FR + FV
PC	Percent change in index	(FI - FI[t-1]) / FI[t-1]

Table 3.2.1: Prefixes of the Z.1 codes

15 The second field consists of a two digit number representing the sector. The sectors included in this study are shown in table 3.2.2, a full listing of the sectors in the IMA is available on the Fed website (see footnote p.143). There is a hierarchical structure to the codes which is not shown in the table. Codes in parentheses against some items give the corresponding code from SNA 2008, the international standard for national accounting (OECD 2008).

[4]These descriptions of the time series structure are reproduced from the Fed website https://www.federalreserve.gov/apps/fof/SeriesStructure.aspx

Code	Sector
10	Nonfinancial corporate business
11	Nonfinancial noncorporate business
15	Households and nonprofit organizations (S14+S15)
20	State and local governments
26	Rest of the world (S2)
31	Federal government (S1311)
79	Domestic financial sectors (S12)
88	All domestic sectors (S1)
89	All sectors

Table 3.2.2: The Z.1 sector identifiers for the time series used in this study.

30611 The third field is the *instrument* representing the individual flow or stock. As the length of the field suggests, there are a large number of these, a full listing is available on the Fed website (see footnote p.143). Examples are GDP, 69025; Compensation of employees received, 60251; Net acquisition of financial assets, 40900; Revaluation account for Nonfinancial assets, 20100. A listing of all the codes used in the study is provided in table 3.2.8.

0 The fourth field is normally zero, but may take other values. Its value is not significant.

5 The fifth field of the code, the ninth digit, is a single number that indicates whether the series is an input series or a calculated series in the accounts.

Digit 9	Description (Input/Calculated)
0	Input series with seasonal factor
1	Input series from National Income and Product Accounts (NIPA)
3	Input series with zero seasonal factor
5	Computed series
6	Percent series

Table 3.2.3: The Z.1 codes

.Q The final field indicates the series frequency; it is either 'A' or 'Q' indicating an annual or quarterly series.

3.2.1.2 The Download Process

The Federal Reserve website makes the time series available for individual download, or grouped into related tables representing particular accounts, or as a bulk download of all time series in a single `XML` file, which is the approach that has been taken here. The downloaded `XML` file is unpacked and the time series required for the study are extracted by a series of programs developed specifically as part of this project using the *R language and environment for statistical computing* (R Core Team 2017). The programs and their inter-relationships are depicted in figure 3.2.1. The source code of the programs themselves are available on `GitHub`[5].

The overall goal of the download process is to construct a comprehensive version of the national income accounts, broken down into seven sectors[6], showing the complete progression from the production and income accounts, through distribution of income to arrive at gross saving and its allocation in the capital account (investment) and the financial account (Net Acquisition of Financial Assets (NAFA) and Net Incurrence of Liabilities (NIL)) resulting in the sectoral balances stated in terms of Net Lending/Borrowing (NLB)[7]. The sectoral

[5] GitHub is an open access web-based repository and hosting service providing distributed version control and source code management using git. Git is the underlying version control system for tracking changes in computer files and coordinating work on those files among multiple people. The specific repository for this project is at https://github.com/grasmith/TimeSeries

[6] Households, non-financial corporations, non-financial non corporations, the financial sector, the federal government, state and local governments, and the rest of the world

[7] In principle, net lending/borrowing on the capital account (NLB(Cap)) should be the same as that on the financial account (NLB(Fin)) but in practice there is always a statistical discrepancy owing to the different types of measurement involved.

balances pass via the revaluation account to arrive at an updated balance sheet for each sector for each period.

In IT terms, it is a three dimensional structure with *instruments* or accounts along one dimension, sectors along the second and time periods along the third. The purpose of this structure is to serve as an intermediate stage, to assemble all the time series required for the later analysis in a single structure to verify its coherence and consistency, that everything balances, totals and cross-checks, and to check its 'stock-flow consistency' since it is the source data for the later analysis. With that assurance, the individual time series can be picked from this structure for use in the model in later chapters with some degree of confidence in their coherence and consistency.

Figure 3.2.1 is a schematic showing the inter-relationships of the `R` programs involved in the download. It shows that there are two main inputs to the download process, the `XML` file containing the time series and a spreadsheet containing codes which specify which of the time series in the `XML` file are to be extracted for use in later chapters.

The spreadsheet contains two sheets which are almost exact replicas of each other, structured according to the set of accounts described in the previous paragraph, except that the `codes` sheet contains the Z.1 codes for the time series required to populate all the cells in the accounts (so the input to the download process) and the second `data` sheet contains a view of one of the outputs of the process — it is a view into the accounting matrix which is the structure holding all the extracted time series, the `data` sheet shows the accounting matrix for 2016Q4. Figure 3.2.2 shows the two together, the top screenshot is part of the `codes` sheet showing the Z.1 codes relevant to each

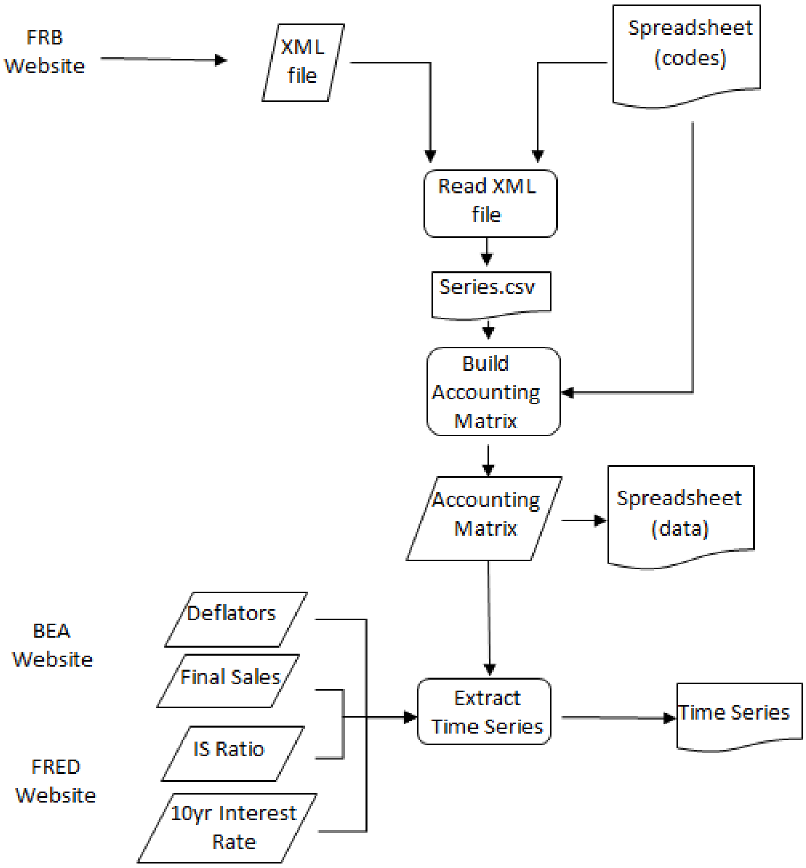

Figure 3.2.1: The structure of the R programs involved in the download process

Description	Code	Shortname	HH.NPISH	NF.Corp	NF.Ncorp	Fin	Gov	All.Sectors	ROW
Gross value added (income approach)	69025	GDP	FA156902505	FA106902501	FA116902505	FA796902505	FA366902505	FA896902505	
Less: Consumption of fixed capital	63000	CFC	FA156300003	FA106300083	FA116300001	FA796300081	FA366300003	FA886300091	
Equals: Net value added	**69026**		**FA156902605**	**FA106902605**	**FA116902605**	**FA796902605**	**FA366902605**	**FA896902601**	
Compensation of employees paid	60250	EmpCompP	FA156025005	FA106025005	FA116025001	FA796025005	FA366025001	FA896025001	
Taxes on production and imports less subsidies	62401	NITpd	FA156240101	FA106240101	FA116240101	FA796240101		FA896240101	
Net Operating surplus (pd)	64021	NOS	FA156402101	FA106402101	FA116402105	FA796402101	FA366402101	FA896402101	
Net Domestic Income (NDI)									
Plus: Income receipts from the rest of the world	69040	IncFrROW							FA266904095
Less: Income payments to the rest of the world	69041	IncToROW							FA266904195
Net national income/Balance of primary incomes	**61400**	**NNI**	**FA156140005**	**FA106140005**	**FA116140001**	**FA796140005**	**FA366140005**	**FA896140001**	
Compensation of employees received	60251	EmpCompP	FA156025105					FA156025105	
Taxes on production and imports receivable	62400	NITrc					FA366240001	FA896240001	
Subsidies paid	64020	subs					FA366402015	FA366402015	
Net Operating surplus (rd)	64021		FA156402101	FA106402101	FA116402105	FA796402101	FA366402101	FA896402101	
Property income (received)	61501	PrpIncRc	FA156150105	FA106150105	FA116130101	FA796150105	FA366150105	FA896150105	
Less: Uses of property income (paid)	61500	PrpIncPd	FA156130001	FA106150005	FA116150005	FA796150005		FA896150005	
Net national income/Balance of primary incomes	**61400**		**FA156140005**	**FA106140005**	**FA116140001**	**FA796140005**	**FA366140005**	**FA896140001**	

Description	Code	HH.NPISH	NF.Corp	NF.Ncorp	Fin	Gov	All.Sectors	ROW
Gross value added (income approach)	69025	2387.283	9186.685	3380.568	1543.571	2441.883	18939.99	0
Less: Consumption of fixed capital	63000	506.885	0	325.033	213.588	528.808	2949.957	0
Equals: Net value added	**69026**	1880.398	7811.042	3055.535	1329.983	1913.075	15989.989	0
Compensation of employees paid	60250	892.928	5415.922	1059.79	737.067	1923.316	10029.024	0
Taxes on production and imports less subsidies	62401	178.368	792.777	195.042	76.338	0	1242.481	0
Net Operating surplus (pd)	64021	809.102	1602.343	1800.703	516.578	-10.241	4718.484	0
Net Domestic Income (NDI)	**0**	1880.398	7811.042	3055.535	1329.983	1913.075	15989.989	0
Plus: Income receipts from the rest of the world	69040	0	0	0	0	0	0	882.056
Less: Income payments to the rest of the world	69041	0	0	0	0	0	0	653.139
Net national income/Balance of primary incomes	**61400**	**14196.461**	**810.378**	**26.109**	**515.285**	**670.675**	**16218.907**	**0**
Compensation of employees received	60251	10014.942	0	0	0	0	10014.942	0
Taxes on production and imports receivable	62400	0	0	0	0	1304.101	1304.101	0
Subsidies paid	64020	0	0	0	0	-61.62	-61.62	0
Net Operating surplus (rd)	64021	809.102	1602.343	1800.703	516.578	-10.241	4718.484	0
Property income (received)	61501	3925.672	577.956	22.27	2101.513	125.076	6752.486	0
Less: Uses of property income (paid)	61500	575.154	1361.556	1776.506	2156.508	672.082	6541.806	0
Net national income/Balance of primary incomes	**61400**	**14196.461**	**810.378**	**26.109**	**515.285**	**670.675**	**16218.907**	**0**

Figure 3.2.2: The two spreadsheets marking the input and output of the download process

Top: The code sheet; Bottom: Sheet displaying time series values for 2016Q4 combination of account and sector; the bottom screenshot shows part of the `data` sheet showing the actual numerical data values for the same combinations of account and sector, the values being those for 2016Q4.

All of the time series that are used in the following chapters are listed in the tables that follow. There are two types — 'atomic' series just use a single Z.1 time series, although it may be the sum of several sectors; these are listed in table 3.2.8 at the end of the chapter. Composite series, listed in table 3.2.4 which follows, are formed by combining various atomic series and possibly other composite series. References to lines in these tables will be given from later chapters to specify the origins of the data.

No	Symbol	Description	Formula
1	G	Total Government Expenditure	$C_G(A:2) + I_G(A:6)$
2	θ_{T_T}	Government Income Share	$Y_G(A:8)/GDP(A:1)$
3	μ	Propensity to Import	$M(A:4)/GDP(A:1)$
4	FS	Fiscal Stance	$G(C:1)/\theta_{T_T}(C:2)$
5	θ_{T_x}	Tax Rate	$TX_{rd_G}(A:15)/GDP(A:1)$
6	NFI	Net Foreign Income	$Inc_{F+}(A:10) - Inc_{F-}(A:11)$
7	X_T	Total Exports	$X(A:5) + NFI(C:6)$
8	TR	Trade Ratio	$X_T(C:7)/\mu(C:3)$
9	$CFTR$	Combined Fiscal and Trade Ratio	$(G(C:1) + X_T(C:7))/(\theta_{T_T}(C:2) + \mu(C:3))$
10	NFA_P	Net Financial Assets(pvt)	$TFA_P(A:37) - TL_P(A:39)$
11	NLB_{stk_P}/YD_P	NLB Stock/Prv Disp Income	$NLB_{stk_P}(A:42)/YD_P(A:9)$
12	NFA_G	Net Financial Assets(gov)	$TFA_G(A:38) - TL_G(A:40)$
13	NFA_G/GDP	Net Financial Assets(gov)/GDP	$NFA_G(C:12)/GDP(A:1)$
14	NFA_G/Y_G	Net Financial Assets(gov)/Gov't Income	$NFA_G(C:12)/Y_G(A:8)$
15	PX	Private Expenditure	$C_P(A:3) + I_P(A:7)$
16	TT_F	Net Tax Tfr (RoW)	$TTfr_{F+}(A:25) - TTfr_{F-}(A:26)$
17	Tfr_{pd_P}	Transfers Paid (pvt)	$SI_{pd_P}(A:22) + OT_{pd_P}(A:23)$
18	Tfr_{rd_P}	Transfers Rec'd (pvt)	$SB_{rd_P}(A:21) + OT_{rd_P}(A:24)$
19	$TTfr_P$	Net Transfers (pvt)	$Tfr_{pd_P}(C:17) + Tfr_{rd_P}(C:18)$
20	TT_P	Tot Tax Tfr (pvt)	$TX_{pd_P}(A:16) + TTfr_P(C:19)$
21	Tfr_{pd_G}	Transfers Paid (gov)	$SC_{pd_G}(A:17) + OT_{pd_G}(A:20)$
22	Tfr_{rd_G}	Transfers Rec'd (gov)	$SI_{rd_G}(A:18) + OT_{rd_G}(A:19)$

No	Symbol	Description	Formula
23	$TTfr_G$	Tot Transfers (gov)	$Tfr_{pd_G}(C:21) + Tfr_{rd_G}(C:22)$
24	TT_G	Tot Tax Tfr (gov)	$TX_{rd_G}(A:15) + TTfr_G(C:23)$
25	GNI	Gross National Income	$GDP(A:1) + NFI(C:6)$
26	$\Sigma NLB(fin)_P$	Cumulative NLB(fin) (pvt)	$\Sigma NLB(Fin)_P$
27	$\Sigma NLB(cap)_P$	Cumulative NLB(cap) (pvt)	$\Sigma NLB(Cap)_P$
28	$\Sigma NLB(cap)_G$	Cumulative NLB(cap) (gov)	$\Sigma NLB(Cap)_G$
29	$\Sigma NLB(cap)_F$	Cumulative NLB(cap) (row)	$\Sigma NLB(Cap)_P$

Table 3.2.4: The ‘Computed’ time series

A:’ refers to the line number in table 3.2.8;

‘C:’ refers to the line number in this table.

3.2.2 The Eurostat Data

The particular source of data is the table `nasa_10_nf_tr` which is a table of 'non-financial' transactions from the national annual sector accounts. An interactive version of the accounts is available on the Eurostat website (Eurostat 2018), but the data used here have been downloaded direct from the database by a package `pdfetch` written for the *R language and environment for statistical computing* (R Core Team 2017).

The specific data downloaded is shown in table 3.2.5.

Accounts		Sectors		Countries	
Code	Description	Code	Description	Code	Description
B1G	Gross Value Added	S1	Total Economy	BE	Belgium
B12	Current External Balance	S13	Government	DK	Denmark
B9	Net Lending and Borrowing	S2	ROW	DE	Germany
OTE	Total Government Expenditure			EL	Greece
OTR	Total Government Revenue			ES	Spain
P6	Exports of Goods and Services			FR	France
P7	Imports of Goods and Services			IE	Ireland
D5	Taxes on Wealth and Income			IT	Italy
				NL	The Netherlands
				AT	Austria
				PT	Portugal
				FI	Finland
				SE	Sweden
				UK	United Kingdom

Table 3.2.5: Data Selections from Eurostat table `nasa_10_nf_tr`

3.2.3 Miscellaneous Data

Some additional items of data have been taken from the BEA website and the Federal Reserve Economic Database (FRED); details are provided in the following tables

3.2.3.1 The Bureau of Economic Analysis (BEA)

To compute the inventory-sales ratio requires sales data which are downloaded from the BEA website. The price deflators for the time series are also sourced from the BEA.

Line	Data Item	Table	Lines
1	US Final Sales of Domestic Product	Table 1.2.5	lines 2 - 13
2	Implicit Price Deflators for Gross Domestic Product	Table 1.1.9	lines 1 - 20

Table 3.2.6: BEA Data
Website: http://www.bea.gov/iTable/index_nipa.cfm

3.2.3.2 The Federal Reserve Economic Data (FRED)

The following data items are dwonloaded from the FRED database.

Line	Data Item	URL
1	US 10 year interest rate	https://fred.stlouisfed.org/series/DGS10
2	US Inventory-Sales Ratio	https://fred.stlouisfed.org/series/ISRATIO

Table 3.2.7: FRED Data

No	Symbol	Description	Sectors							
			HH	NF corp	NF Ncorp	Fin	F.Gov	S.Gov	All	ROW
1	GDP	Gross Domestic Product							FA896902505	
2	C_G	Government Consumption					FA316901001	FA206901001		
3	C_P	Private Consumption	FA156901001							
4	M	Imports								FA266903001
5	X	Exports								FA266903011
6	I_G	Government Investment					FA315050905	FA205050905		
7	I_P	Private Investment	FA155050905	FA105050985	FA115050985	FA795015085				
8	Y_G	Government Income					FA316012005	FA206012005		
9	YD_P	Private Disposable Income	FA156012095	FA106012095	FA116012005	FA796012095				
10	Inc_{F+}	Foreign Income Rec'd								FA266904095
11	Inc_{F-}	Foreign Income Paid								FA266904195
12	SD_{gdp}	Statistical Discrepancy							FA087005995	
13	NNI_G	Net National Income (gov)					FA316140005	FA206140005		
14	NNI	Net National Income							FA896140001	
15	TX_{rd_G}	Tax Received(gov)					FA316220001	FA206220005		
16	TX_{pd_P}	Tax Paid(pvt)	FA156220001	FA106220001		FA796220001				
17	SC_{pd_G}	Social Contributions Pd					FA316404001	FA206404001		
18	SI_{rd_G}	Social Ins Contrib Rd					FA316601001	FA206601001		
19	OT_{rd_G}	Other Tfr Rd (gov)					FA316403105	FA206403105		
20	OT_{pd_G}	Other Tfr Pd (gov)					FA316403001	FA206403001		
21	SB_{rd_P}	Soc Ben Rd	FA156404105							
22	SI_{pd_P}	Soc Ins Pd	FA156600001							
23	OT_{pd_P}	Other Tfr Pd (pvt)	FA156403001	FA106403001	FA116403001	FA796403005				

No	Symbol	Description	Sectors							
			HH	NF corp	NF Ncorp	Fin	F.Gov	S.Gov	All	ROW
24	OT_{rd_P}	Other Tfr Rd (pvt)	FA156403101							
25	$TTfr_{F+}$	Tax Tfr to ROW								FA266400101
26	$TTfr_{F-}$	Tax Tfr fm ROW								FA266400201
27	CT_P	Cap Trfrs (pvt)	FA155440005	FA105440005	FA115440005	FA795440005				
28	CT_G	Cap Trfrs (gov)					FA315440005	FA205440005		
29	CT_F	Cap Trfrs (row)								FA265440005
30	$NLB(Fin)_P$	NLB Fin A/c (pvt)	FA155000005	FA105000005	FA115000005	FA795000005				
31	$NLB(Cap)_P$	NLB Cap A/c (pvt)	FA155000905	FA105000905	FA115000905	FA795000905				
32	$NLB(Cap)_G$	NLB Cap A/c (gov)					FA315000905	FA205000905		
33	$NLB(Cap)_P$	NLB Cap A/c (RoW)								FA265000905
34	Inv	Inventories		FL105020015	FL115020005					
35	Cap	Non-Fin Assets	FL152010005	FL102010005	FL112010005	FL792010095	FL312010095	FL212010095		
36	$Hous$	Housing Wealth	LM155035005	LM105035005	LM115035005					
37	TFA_P	Total Financial Assets (pvt)	FL154090005	FL104090005	FL114090005	FL794090005				
38	TFA_G	Total Financial Assets (gov)					FL314090005	FL214090005		
39	TL_P	Total Liabilities (pvt)	FL154190005	FL104194005	FL114190005	FL794194005				
40	TL_G	Total Liabilities (gov)					FL314190005	FL214190005		
41	NW	Net Worth	FL152090005	FL102090085	FL112090205	FL792090095				
42	NLB_{stk_P}	NLB Stock(pvt)	FL155000005	FL105000005	FL115000005	FL795000005				
43	NLB_{stk_G}	NLB Stock(gov)					FL315000005	FL215000005		
44	NLB_{stk_F}	NLB Stock(RoW)								FL265000005

No	Symbol	Description	Sectors							
			HH	NF corp	NF Ncorp	Fin	F.Gov	S.Gov	All	ROW

Table 3.2.8: The atomic time series and the Z.1 codes of their constituent time series.

The full Z.1 code is formed by adding the suffix .Q to each time series code in columns 5-12 since all time series are quarterly.

Chapter 4

Macroeconomic Ratios

This chapter and the next will investigate the macroeconomic ratios employed in Godley's models. The use of ratios as an effective way of scaling and assessing quantitative magnitudes was introduced in section 2.2.1 (p.47) which described the two sets of ratios he used — what have been called here the *flow* ratios and the *stock-flow* ratios — and how he used these in combination to understand how they affected the dynamics of a macroeconomy. He asserted that the flow ratios act as 'drivers' of the economy, they determine the level of the injections from the public and foreign sectors into the private sector, impacting private sector income and expenditure and hence the private sector balance. Any non-zero private sector balance results in a flow of net financial assets between sectors. The willingness of one sector to hold assets issued by the other two is captured by the stock-flow norms. These act as stabilisers, and the levels of national income, private expenditure and the stock of private financial assets mutually adjust to these norms through the action of partial adjustment processes (defined earlier in section 2.2.2.1). The parameters of the flow ratios and the partial adjustment processes relate to structural characteristics of the economy and their relative magnitudes determine whether an economy will be a ‘surplus’ economy, i.e. tending to run fiscal and current account surpluses, or a ‘deficit’ or ‘mixed’ economy; this classification will be explored further in chapter 5.

The study of the ratios will be split between this chapter and the next. This chapter focuses on the ratios themselves with the aid of historical data from the US IMA. The next chapter shows how they interact — it draws the various ratios together into a dynamic system and explores their behaviour by means of computational simulations.

The flow ratios are the *fiscal stance* (FS), the *trade ratio* (TR) and the *combined fiscal and trade ratio* (CFTR). Their derivation from the three balances analysis of the ‘New Cambridge School’ was demonstrated in section 2.2.1.1 where they were described as conditions for financial balance of the sectors of the economy. The properties of these ratios will be studied in section 4.1 using historical data from the US IMA.

The stock-flow ratios, were introduced in section 2.2.1.3, they serve both as indicators of economic imbalances and stabilisers in the macroeconomic dynamics. Their empirical properties will be investigated here in section 4.2. The key issue to be addressed in this investigation is the stability of the ratios over time and what degree of stability is required for a ratio to qualify as a norm. The criterion employed here is time series stationarity, which was explained in section 3.1.2.1. For the purposes of the analysis, the stock-flow ratios are divided into two groups: the first group contains those ratios that arise in the high-level three sector model to be developed in later chapters.

This model is an implementation of the New Cambridge three balances analysis discussed earlier in section 2.1.2; in this model, imbalances between the sectors give rise to financial inter-sectoral flows leading to changes in the stocks of financial assets of each sector. So the relevant stock-flow ratios are the stocks of net financial assets to income for each sector, and these are the subject of section 4.2.1. The ratios in the first group only involve financial assets; the second group involve non-financial assets and arise in models where the private sector is further disaggregated into households, firms and the financial sector, although that disaggregation is not pursued in this present work, it is briefly described in chapter 7 under 'Next Steps'. The most important non-financial stocks in this model are inventories and fixed capital, leading to the study of the inventory-sales ratio and the capital-output ratio as stock-flow norms.

Finally, section 5.8 concludes the work of this chapter.

4.1 The Flow Ratios

In this section the three flow ratios will be further explored, they were first introduced in section 2.2.1.1 and their connection to the multiplier was developed in section 2.2.1.2; the following is a brief reprise. From the national income identity

$$C + S + T \equiv Y \equiv C + I + G + (X - M)$$

the three balances condition follows by rearrangement of terms,

$$(S - I) + (T - G) \equiv (X - M)$$

(C is consumption expenditure, S is savings, T is taxes and transfers, Y is national income,

I is investment expenditure, G is government expenditure, X is total exports and M is total imports)

So private sector saving plus public sector saving is equivalent to the current account surplus. Each of the bracketed terms in the expression constitutes the balance condition for one of the three sectors. In 'equilibrium', each term will be zero, taxes and transfers equal government expenditure $T = G$, exports equal imports $X = M$ and savings equal investment $S = I$. More commonly, there will be some non-zero balances leading to a transfer of financial assets between sectors. The equilibrium situation could be regarded as a 'pure flow model' whereas the imbalance situation could be thought of as a 'stock-flow model' since changes in financial assets between sectors become important, and the stock-flow ratios come into play.

4.1.1 The Fiscal Stance

The condition for sectoral balance for the public sector is $(T - G) = 0$, and if we assume that T is a function of income, $T = \theta Y$, where θ is the average government share of national income, then when $Y = \frac{G}{\theta}$, the public sector is in balance; the term $\frac{G}{\theta}$ is called the *fiscal stance* (Godley & Cripps (1983, p.111), Godley & Lavoie (2007c, p.72)). The name was chosen for the good reason that if national income exceeds the fiscal stance ($Y > \frac{G}{\theta}$), then $\theta Y > G$ and the public sector is running a surplus; conversely, if national income is less than the fiscal stance ($Y < \frac{G}{\theta}$), the public sector is running a deficit. This latter situation is said to be an 'expansionary' fiscal stance (and the former 'contractionary'), since there is a flow of funds from the public sector to other sectors — 'injections' of government expenditure into the economy exceed 'leakages' from taxation. This assumes that the injections are going into the domestic economy, i.e. the private sector, but with a large current account deficit, they could be leaking abroad. This was the essence of the debate around the *New Cambridge* school in the 1970s. Conventional Keynesian thinking was that low levels of unemployment could be maintained by managing aggregate demand partly through government expenditure, hence stimulating the economy to raise output, in other words adopting an expansionary fiscal stance. But the New Cambridge group pointed out that with a large current account deficit, much of the stimulus would go to increasing imports rather than raising domestic output and employment. This is the *twin deficits* hypothesis described earlier on page 35 of section 2.1.2.

The plot in figure 4.1.1 shows the history of the fiscal stance in relation to national income for the US between 1960 and 2016.

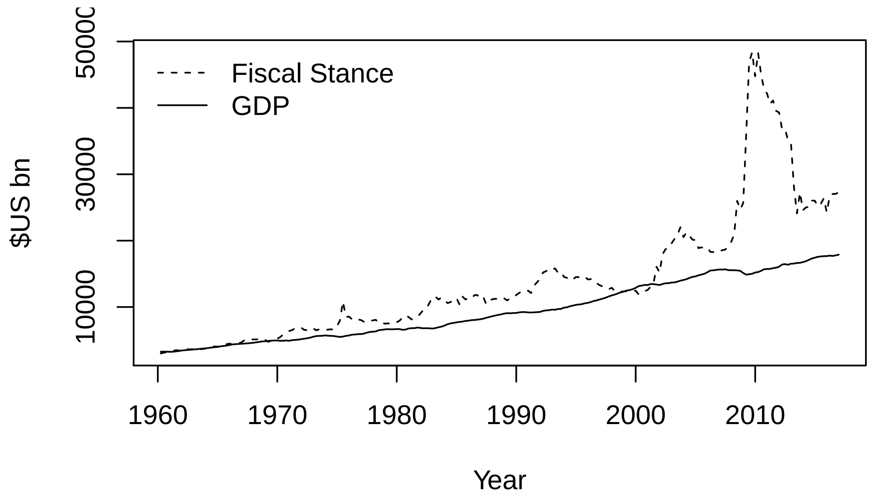

Figure 4.1.1: The US Fiscal Stance, 1960-2016

Source: US IMA
Fiscal Stance (C:4)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Values adjusted by deflator for GDP
from BEA NIPA Table 1.1.9 "Implicit Price Deflators for GDP".

The ratio normally tracks just above GDP as the government usually runs a small deficit, however there was a period in the late 1990s where the government was running a surplus. The effects of this exceptional fiscal stance were analysed in Godley (1999a). The extreme peak at the time of the financial crisis was due to the collapse of tax receipts and a sharp rise in government fiscal transfers.

In computing the fiscal stance, there are choices to be made concerning the data series to be used. Government expenditure could be simply government consumption, or total government expenditure including investment. The figure for θ could be simply the ratio of taxes to national income, which henceforth is termed θ_{T_x}, or it could be government net disposable income which is government revenue after all taxes and transfers, denoted by θ_{T_T}. In figure 4.1.1, the more comprehensive values of total government expenditure and θ_{T_T} have been used.

4.1.1.1 The Government Share of National Income (θ)

This section will use empirical data from the US IMA to justify the choice of the functional form of the relationship between government revenue and national income and the choice of what is to be included in the ratio θ.

Any analysis based on the fiscal stance relies on the relationship between national income (Y) and the government share of national income T, but, as the discussion in the previous section indicated, there are different measures available for government revenue, the two discussed above were government tax receipts and total government revenue after transfers. The following figures from the accounts for the government sector for 2016Q4 illustrate the difference,

2016Q4		
Government Contribution to Value Added	670.675	
Taxes received	2456.213	$\div$ *GDP*, $\theta_{T_x} = 0.13$
Social Contributions Received	2052.750	
Gross Government Income	5179.638	
Transfers Paid	3377.43	
Net Government Income	1802.208	$\div$ *GDP*, $\theta_{T_T} = 0.10$

The relative merits of using θ_{T_x} or θ_{T_T} will be investigated in the following sections, and also the justification for using an *average* rate (θ) giving a form of the equation for government income of $T = \theta Y$, as opposed to a *marginal* rate θ_1 and the following form $T = \theta_0 + \theta_1 Y$.

4.1.1.1(a) Total Taxes and Transfers (θ_{T_T}) Figure 4.1.2 gives a scatter plot of total government revenue after taxes and transfers (YG) against national income (Y) for the US for the period between 1960 and 2016. Since the values are ratios of current values, there is no need to apply a deflator.

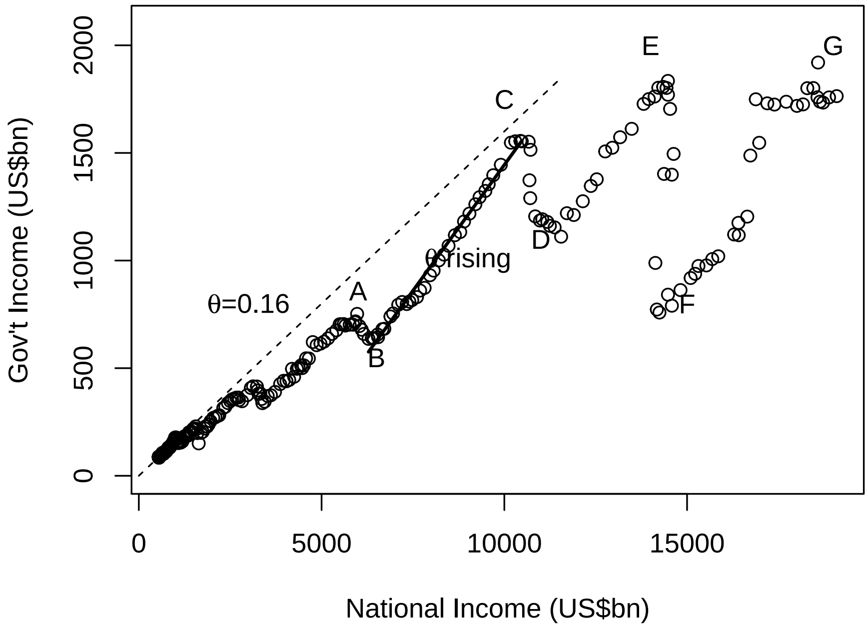

Figure 4.1.2: US Government Income vs National Income

Source: US IMA
Government Income (A:8)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
Data: ratios of nominal values

There appears to be a relationship but it is not a constant one — there are periods of a quasi-constant relationship where government revenue grows in line with national income, interspersed with sudden downturns marking the recessions where government revenue declines due to falling tax receipts and increased transfer payments. These downturns are followed by recovery periods where revenue gradually re-converges towards its previous trend. The dotted line $\theta = 0.16$ represents an average rate in the early part of the period, but towards which the rate appeared to be converging again in the period BC, the runup to the dotcom bubble. In the 'inter-bubble' recovery period DE the rate again seems to be converging on $\theta = 0.16$ but at a much slower rate. The post-crisis recovery FG is converging even more slowly.

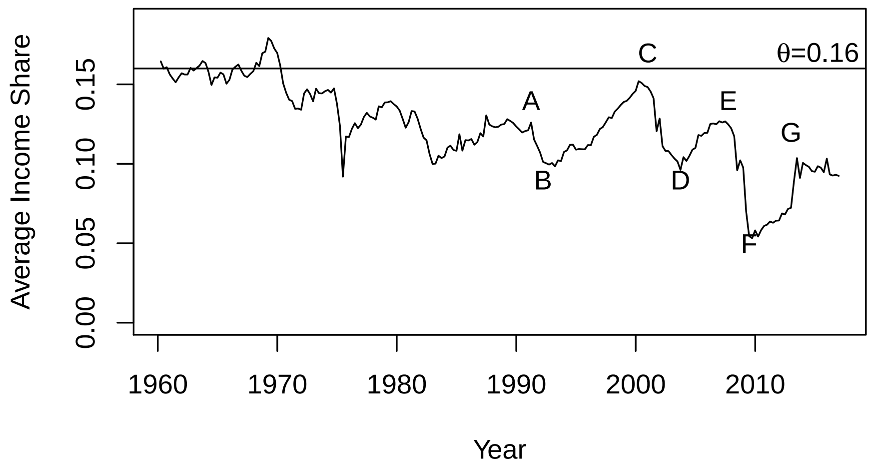

Figure 4.1.3: US Government Income Share, 1960 - 2016.

Source: US IMA
Government Income Share (C:2)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: ratios of nominal values

Figure 4.1.3 plots the evolution of the government's income share against time over the same period, showing the same time points as in the previous figure. The pattern appears to fall into three phases, in the 1960s the government income share fluctuated around 16% of GDP, then started a decline in the period leading up to time point A (1991Q1). In this period, the recovery from the recessions is 'V-shaped', i.e. the recovery is short and rapid but at each successive recession, the income share does not fully recover to its pre-recession level. There is a gradual ratcheting down over the thirty year time period, so that by the mid-1980s it is down to roughly 13%. In the period after time point A, the pattern changes to one where the recovery from the recessions is no longer V-shaped, but is more gradual, and following time point C (2000Q4), each recovery fails to restore the pre-recession income share. The segment BC is the period of the recovery from the recession of the early 1990s to the peak of the dotcom bubble. It coincides approximately with the period of the Clinton administration. This was a period of restrictive fiscal policy as discussed in Godley (1999a) in which he argued that the contractionary fiscal stance in this period was one of the 'Seven Unsustainable Processes' in the period leading up to the collapse of the dotcom bubble. Time point C represents a high point in the government revenue ratio and appears in figure 4.1.1 as the point where the fiscal stance was less than GDP. The collapse of the dotcom bubble is represented by the plunge from C to D. In the inter-bubble period DE, the government income share gradually recovered but was interrupted by the global financial crisis at point E. The drop from E to F is the effect of the crisis and the post-crisis recovery from F to G was initially quite rapid but gives the impression of having levelled off at an income share around 10%.

The Functional Form of the Function for Government Revenue The relationship between government income and national income is usually represented as a direct function of the form

$$T_T = \theta_{T_T} \cdot Y \tag{4.1}$$

where T_T is government income after taxes and transfers and θ_{T_T} is $T_T \div Y$. Every point in the plot in figure 4.1.2 represents a different pair (T_T, Y) and will result in a different value of θ_{T_T} which represents an *actual* rate for that time point. If a regression through the origin is taken for some part of the sample, an *average* rate will result. If, however, a regression line for a sub-sample like BC is calculated, it will have an intercept and slope resulting in an estimated equation of the form $T_T = T_{T0} + \theta_{T_T} \cdot Y$ and θ_{T_T} will represent a *marginal* revenue rate.

The question of the average or marginal rate is reflected in the functional form of the equation. In figure 4.1.4, a line from the origin to each point in the plot represents the actual rate T/Y in that period and, in the situation depicted, with a non-zero intercept, the value will be different at each point, whereas the slope of the fitted line represents the marginal rate, $\Delta T/\Delta Y$ which is the growth in T relative to the growth in income Y and may be stable over a number of time periods.

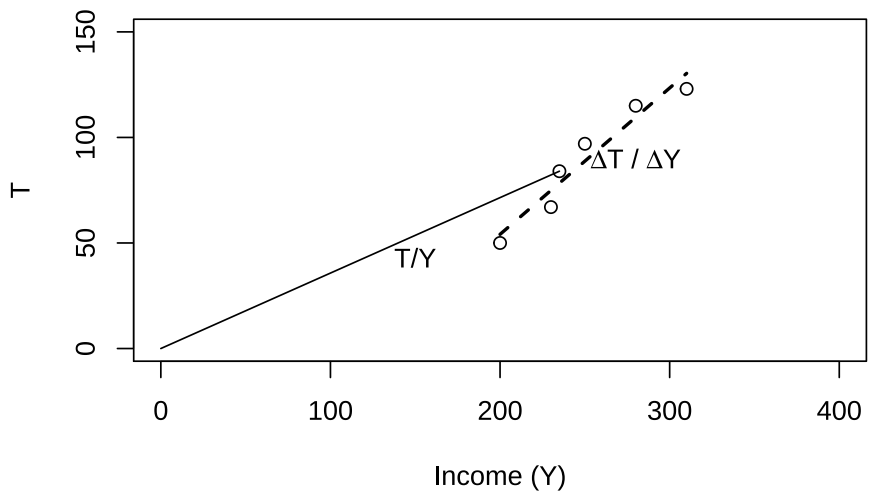

Figure 4.1.4: Schematic: The average rate and the marginal rate

In the simulations to follow in chapter 6, it will be convenient to represent the revenue relation in the simple direct form of equation 4.1 without an intercept so that θ_{T_T} represents an average rather than a marginal rate. Figure 4.1.2 suggests that this would be quite a close approximation up to time point

C, but also that, even during the instability of recent decades, the revenue rate appears to re-converge to a relationship of this form, although the rate seems to be moving lower in later periods. Hence, this approximation will be made throughout chapter 6, where the average value derived from a regression over the entire time range of $\theta_{T_T} = 0.12$ will be used. However, in specific sub-periods e.g. OA, BC, DE or FG, an intercept form of the relation with a marginal rate would be a better fit.

4.1.1.1(b) Government Tax Revenue (θ_{T_x})

This section will carry out a similar analysis to that of the previous section based purely on the figure for taxes received by the government before transfer payments, as illustrated on page 163. The scatter plot in figure 4.1.5 plots government tax received against net national income in the years 1960 - 2016. It is segmented into similar phases to that in figure 4.1.2, but is slightly less volatile. The same time points as used in the previous section have been marked on this plot for comparison. The line OT marks the actual tax rate at the peak of the dotcom bubble which is, incidentally, the highest rate throughout the entire period. It represents a tax rate of $\theta_{T_x} = 0.145$ with the corresponding form of equation for OT being $T = 0.145Y$. The dotted line, OT' is an OLS fitted line covering the whole period, representing an overall average tax rate.

As before, figure 4.1.6 shows the actual ratio of tax to national income plotted against time for the same period. The rate appears to form a stationary time series, even if a rather volatile one. The time points from the previous plot are reproduced here, together with the lines OT, OT' and the segments BC, DE and FG.

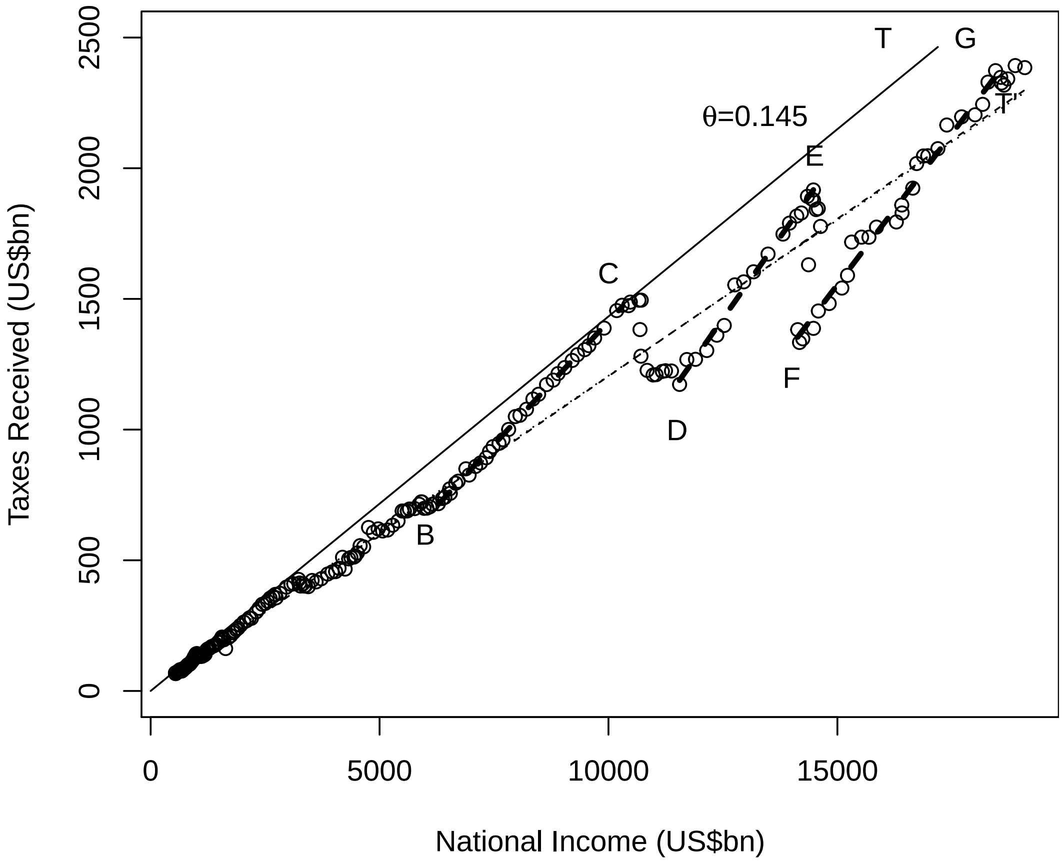

Figure 4.1.5: The US economy: Tax Received vs National Income

Source: US IMA
Tax Received(gov) (A:15)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
Data: ratios of nominal values

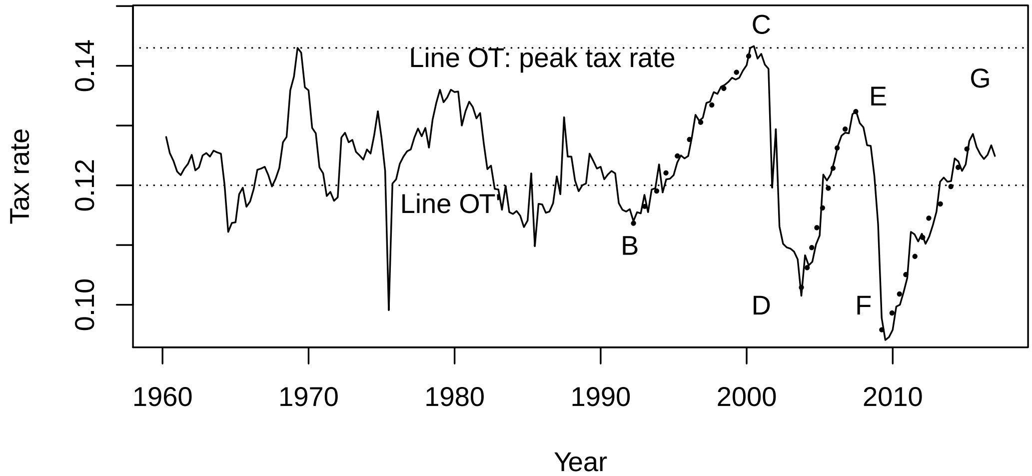

Figure 4.1.6: Variation in the tax rate from 1960 to 2016

Source: US IMA
Tax Rate (C:5)
('C:' refers to the line number in table 3.2.4)
Data: ratios of nominal values

The same considerations concerning the functional form of the tax relation made on page 166 above also apply here. Line OT' is a regression through the origin covering the whole period with equation $T = 0.12Y$; when estimated with intercept and slope, the resulting equation is $T = 13.936 + 0.119Y$. The two lines are effectively indistinguishable, so the regression through the origin is preferred since this is simpler and represents the average tax rate across the period. As stated in the previous section, the option of modelling each sub-period separately as represented by the fitted line segments BC, DE and FG in figure 4.1.5 will yield a better fit in those localized time periods.

4.1.1.1(c) Conclusions: The Government Share of National Income

The purpose of this little digression into government income has been to justify the use of the function $T = \theta Y$ in the simulations that follow. There are two choices to be made, the first concerns the functional form of the expression and the second, which transaction flows should be included in government revenue. These choices are to be made with reference to historical data from the US IMA over the period of the study. The first choice amounts to whether θ should represent the average or the marginal rate of revenue growth with respect to national income. In both figures 4.1.2 and 4.1.5, lines representing an average tax rate, that is, a functional form like $T = \theta Y$, could be formed from a linear regression through the origin that would be a reasonable fit to the data, although the 'goodness' of the fit becomes steadily worse in the later part of the period, especially in the case of total government revenue. The alternative form using a marginal rate, $T = \theta_0 + \theta_1 Y$ does not offer an improvement in general, but fits very well in chosen sub-periods, for example, during the recovery periods following each crisis, 1992-2000, 2001-8, 2009-16. During each of these recovery periods, the average rate is rising, as if to re-converge with the 'long-term' average rate, even though the convergence never finishes before being interrupted by the next crisis. Figures 4.1.3 and 4.1.6 indicate that the government share of national income has been steadily declining since the 1970s; the recovery following each recession doesn't quite reach the previous pre-recession level before the next crisis hits.

Concerning the second choice, whether to use total government income or just tax income, the plots show that total income is much more volatile and declines further and longer during the crises, so that using a simple relation to represent it is going to be a gross approximation. The plot of tax income is more regular, but still shows large discontinuities around the crises. The disadvantage in just using the tax income is that the flows representing transfers would then have to be added to the SFC model in chapter 6 for it to balance, and it doesn't appear that the benefit of a slightly better fit does not offset the added modelling complexity.

In summary, the simulations in chapter 5 and the models in chapter 6 will continue to assume that $T = \theta Y$ where T represents total government revenue TT_T.

4.1.2 The Trade Ratio

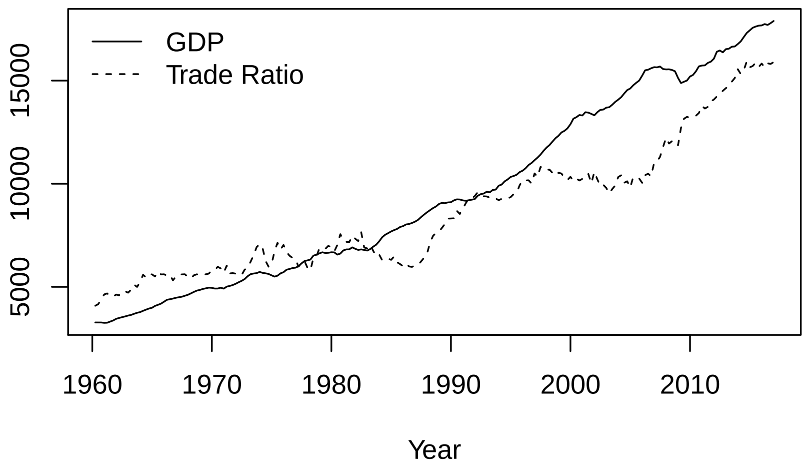

Figure 4.1.7: The Trade Ratio

Source: US IMA
Trade Ratio (C:8)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Values adjusted by deflator for GDP and for Exports
from BEA NIPA Table 1.1.9 "Implicit Price Deflators for GDP".

The analysis in this section will be similar to that for the fiscal stance. The trade ratio [1] will be derived from the balance condition for the foreign sector and its evolution over the sample period studied by reference to data from the US IMA.

[1]The trade ratio was first defined on page 49 and its data definition is given in table 3.2.4 line 8. It is X/μ, where X is 'total exports' which is defined as exports plus net foreign income (table 3.2.4 line 7).

The trade ratio is just a re-statement of Harrod's foreign trade multiplier and this connection leads logically to the concept of *balance of payments constrained growth* which arises out of the three sector model under certain conditions. The key parameter in the trade ratio is μ, the propensity to import, and a similar exercise to that conducted above for the share of government income will be carried out to compare the average and the marginal propensities.

When the foreign sector is in balance, $X = M$, and assuming that M is a function of income $M = \mu Y$, where μ is the average propensity to import, we can write $Y = X/\mu$; the expression X/μ is the *trade ratio* and is the balance condition for the foreign sector. It is called the 'trade performance ratio' in Godley & Cripps (1983, p.296) and Godley & Lavoie (2007c, p.179) but this was later simplified to the *trade ratio* in Godley (1999a)[2] and later writings.

The dynamic implications of the trade ratio are the same as those for the fiscal stance; if $X/\mu = Y$ the current account is balanced, if $Y > X/\mu$ imports exceed exports and the economy is running a current account deficit, and a surplus if $Y < X/\mu$. When $Y < X/\mu$ foreigners demand for domestic goods is greater than imports, i.e. domestic demand for foreign goods, so foreigners are stimulating demand, and hence output in the domestic economy; conversely, an excess of imports would mean that demand is 'leaking abroad'. To achieve balance on the external accounts. a surplus or deficit on the current account must be balanced by movements in the capital account; in the case of a current account deficit, the economy will either be accumulating foreign debts or selling assets abroad, the economy is importing capital. The converse situation of a

[2] Godley actually uses an *adjusted trade ratio* (ATR), defined as X/μ where X is exports of goods and services plus all transfers corrected for price changes and μ is the average import propensity corrected for the business cycle.

current account surplus means that domestic production is being used abroad leading to excess domestic saving which must be invested abroad, either by buying foreign debt or assets, the economy is exporting capital.

The connection between the trade ratio and Harrod's foreign trade multiplier was explained in section 2.2.1.2, and consideration of capital flows can lead to balance of payments constrained growth, which will be explored further in secion 4.1.2.1 below.

The plot in figure 4.1.7 shows the history of the US trade ratio between 1960 and 2016 with values deflated by deflators for GDP and Exports. It shows that the US had a positive current account balance until the late 1970s when the chronic deficits became established in the 1980s. The situation stabilized a little in the 1990s but the 2000s saw the current account deficit really open up in the period leading up to the financial crisis. The gap between income and the trade ratio appears to be stabilising (though not noticeably closing) in the post-crisis period.

4.1.2.1 Balance of Payments Constrained Growth

Harrod proposed the foreign trade multiplier in 1933 (Harrod 1939); by setting up a model of a two sector economy he arrived at the foreign sector balance condition, $Y = X/\mu$, and deduced that the multiplier relating the response of income to changes in exports to be,

$$\frac{\Delta Y}{\Delta X} = \frac{1}{\mu}$$

"the multiplier will always bring the balance of payments back into equilibrium through changes in income following a change in exports"(McCombie & Thirlwall 1994, p.238). Lavoie (2014, p.513) derives a dynamic form of the foreign trade multiplier as,

$$\frac{\Delta Y}{\Delta X}\frac{X}{Y} = \frac{\Delta Y}{\Delta M}\frac{M}{Y}$$

and, since the growth rate $g = \Delta Y/Y$,

$$g = \frac{\Delta Y}{Y} = \frac{\Delta X}{X}(\frac{\Delta Y}{Y}/\frac{\Delta M}{M}) = \frac{\hat{X}}{\Pi}$$

where $\hat{X}$ is the growth rate of exports and Π is the income elasticity of demand for imports. With a current account balance, the growth rate of the economy is determined by the growth rate of its exports divided by the income elasticity of demand for imports. Lavoie (2014, p.514) attributes to Setterfield (2012) the remark that "this is the basic equation of motion for Kaldorians", since Kaldor, in discussions of regional development, referred to Harrod's foreign trade multiplier and tied regional economic growth to the growth rate of its exports (Kaldor 1970).

Thirlwall (2012) narrates how he 'separately discovered' this equation when trying to find reasons for differences in long-term international growth rates. Starting from post-Keynesian assumptions that the economy is demand driven, differences in growth rates required an explanation in terms of demand factors, why were some economies able to expand demand faster than others? The answer he arrived at was that, as demand expands so does the demand for imports and, for some economies, the balance of payments will move into deficit before the full growth potential of the economy has been reached, "in an open economy, the dominant constraint is the balance of payments", and this constraint may become binding before other capacity constraints. The extent to which an economy can run current account deficits is determined by its success in importing capital which, for many developing economies, imposes a limit to economic growth. "In fact, the rate of growth of exports divided by the income elasticity of demand for imports gives such a good approximation to the actual growth experience of major developed countries since 1950 that a new economic law might be formulated" (Thirlwall 1979, p.46), and that is precisely what is now known as Thirlwall's Law.

4.1.2.2 The Propensity to Import (μ)

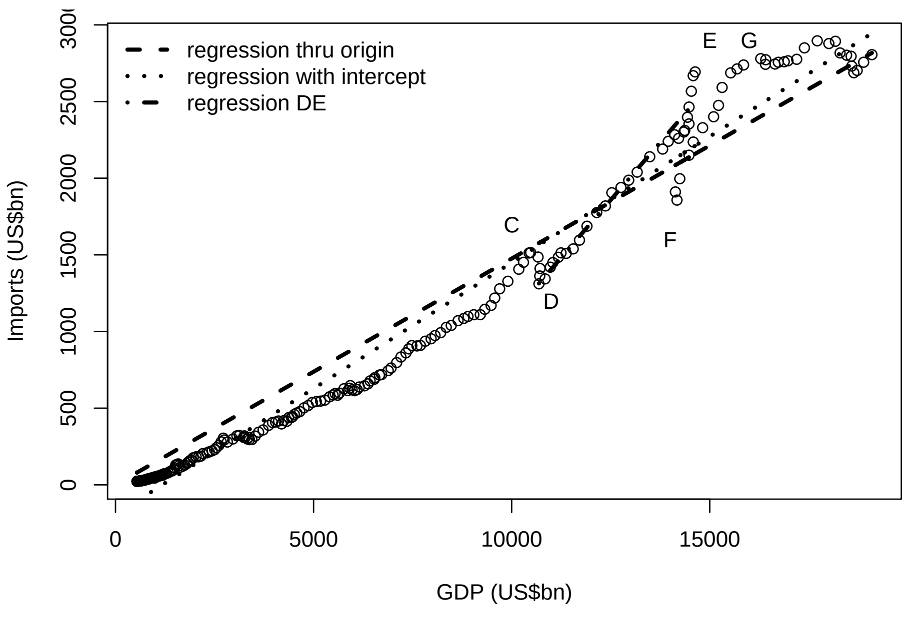

Figure 4.1.8: US Imports vs National Income: 1960 to 2016

Source: US IMA
Imports (A:4)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
Data: ratios of nominal values

In this section, the relationship between imports and national income is explored, the purpose being the same as that for the government income share above, namely to compare alternative functional forms for the import function between one using an average propensity to import, $M = \mu Y$ and one using a marginal propensity to import $M = \mu_0 + \mu_1 Y$. The comparison will be made by reference to historical data from the US IMA.

The scatter plot of imports against GDP in figure 4.1.8 is less disjointed than that in figure 4.1.2 for government revenue, nevertheless, the disturbances accompanying the dotcom bubble and the global financial crisis are clearly discernible. Again, those financial events separate out distinct phases in the import relation — the first leading up to the dotcom bubble (point C), the second being the inter-bubble period where the marginal import rate became steeper (segment DE), and the third being the post-crisis period (segment FG). The vertical pattern EF corresponds to the period of the global financial crisis where income was declining and imports first rose then fell. The pattern post-crisis (FG) is hard to discern but there are indications that the level of imports is settling to a stable level of around 15% as a proportion of national income.

The two dotted lines are OLS regressions, the heavy dotted line is a regression through the origin and represents an average propensity to import, with an import rate given by $M = 0.15Y$. The steeper, lightly dotted line is a regression with an intercept (negative in this case) resulting in the equation $M = -194.63 + 0.16Y$. The marginal and the average rates are only approximately 1 percentage points apart. The regression DE in the inter-crisis period shows that in specific sub-periods the import relation can be quite different from that for the period as a whole.

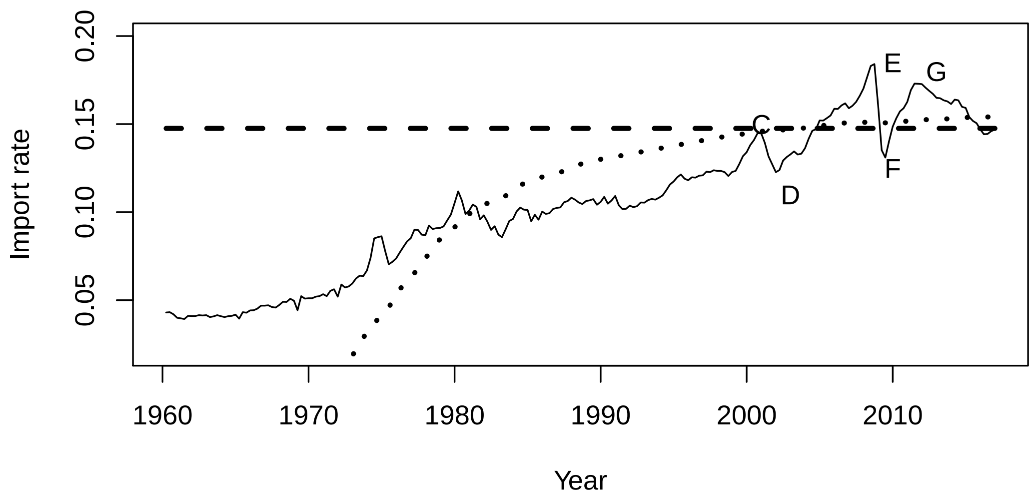

Figure 4.1.9: Imports vs GDP: 1960 to 2016

Source: US IMA
Propensity to Import (C:3)
('C:' refers to the line number in table 3.2.4)
Data: ratios of nominal values

Figure 4.1.9 plots the evolution of the share of imports in the national income for the US over the same period. It indicates that the US propensity to import has been on a steadily rising trend since the early 1970s with periodic breaks in the trend at points C (the peak of the dotcom bubble) and E (the global financial crisis). In the period between the crises, imports showed their fastest rate of increase as the regression line for period DE in figure 4.1.8 makes clear. The regression through the origin from figure 4.1.8 appears in this space as a horizontal line since it represents a constant import rate, whereas the regression with intercept appears as a curved line which is negative in part of its range due to the fact that the intercept in the regression is negative. This line appears to provide a better fit from about 1980 onwards but is poor in earlier periods. The straight line fits well for the period after the year 2000. Although the scatter plot of figure 4.1.8 clearly supports a strong correlation between imports and income, it is equally clear that the relationship is not a simple linear one over the whole time range, due to the disruption of the financial crises and the structural changes to the US economy across the period. Judging by figure 4.1.9, neither of the fitted lines provides a good model, however, the equation $M = \mu \cdot Y$ with $\mu = 0.15$, which fits the later period quite closely, will be used in subsequent sections.

4.1.2.2(a) Conclusions: The Propensity to Import

The purpose of this investigation into US imports has been to justify the use of the functional form $M = \mu Y$ in the simulations that follow. It amounts to whether μ should represent the average or the marginal propensity to import. In figure 4.1.8 an overall average import rate was a reasonable fit to the data; it overstates the import rate in the early part of the period and understates it in the later period — there appears to be a re-convergence to this rate in the post-crisis period. The alternative form using a marginal rate, $M = \mu_0 + \mu_1 Y$ fits very well in chosen sub-periods, for example, during the inter-crisis period shown as line segment DE.

In summary, the simulations in chapter 5 and the models in chapter 6 will continue to assume that $M = \mu Y$ with μ having a value of 15%.

4.1.3 The Combined Fiscal and Trade Ratio

In a three sector economy, the total inflow to the private sector is the sum of government expenditure and exports $G + X$ and the outflow is the sum of taxes and imports which are both assumed to be functions of national income as discussed above, so the total outflow is $(\theta + \mu)Y$. When the sector is in balance, $(\theta + \mu)Y = (G + X)$ or $Y = \frac{G+X}{\theta+\mu}$ and this ratio is called the *Combined*

Fiscal and Trade Ratio (CFTR). If $Y > CFTR$, leakages from the private sector due to taxes and imports exceed injections due to government spending and exports, so the private sector is in deficit, and conversely if $Y < CFTR$. Figure 4.1.10 shows this ratio for the US with GDP deflated values from 1960 to 2016.

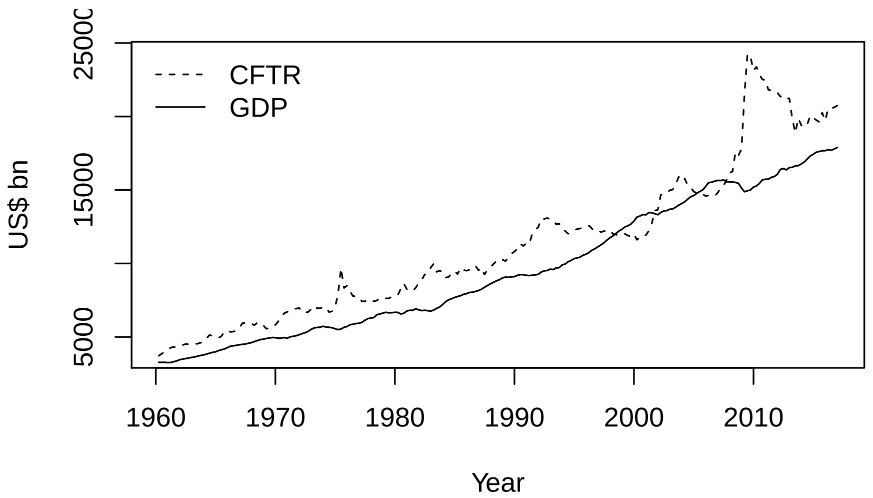

Figure 4.1.10: The Combined Fiscal and Trade Ratio

Source: US IMA
Combined Fiscal and Trade Ratio (C:9)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Values adjusted by deflator for GDP
from BEA NIPA Table 1.1.9 "Implicit Price Deflators for GDP".

It is normal for the private sector to run a small surplus, with the consequence that the stock of private sector financial assets will increase over time. However, the figure shows that, exceptionally, the US private sector was in deficit in two periods — during the dotcom bubble and in the period leading up to the global financial crisis. In such periods the private sector as a whole is losing financial assets (or acquiring debt) which is not sustainable for long. In both cases the correction followed quite quickly.

4.2 The Stock-Flow Ratios

The concept of a stock-flow norm was introduced in section 2.2.1.3 as a stable ratio between a stock variable and its associated flow. It is now time to look a little deeper at stock-flow norms by studying these ratios from different perspectives. The crucial property required of a stock-flow ratio for it to qualify as a *norm* is some degree of stability over time. That is not to say that norms are constants or that they will not change magnitude from time to time to reflect underlying structural changes in the economy, but it does require that they exhibit some degree of 'mean reverting' behaviour over some time interval, even if they display considerable volatility, or variance about their mean.

Two groups of ratios will be investigated, the first in section 4.2.1, are the main sectoral financial ratios for each of the sectors of a three sector economy; these will be central to the model to be developed later in chapter 6. The second group, in section 4.2.2, consists of stocks and flows that arise when the three sector model is disaggregated. This introduces norms relating to non-financial assets, in particular the capital-output ratio and the inventory-sales ratio.

Various ways of looking at norms will be proposed here, the first is to take a purely descriptive approach and study the various ratios by visual assessment of their historical values while relating that to concurrent economic events like the GFC. This study will look at specific examples of stock-flow ratios using empirical data from the US IMA (F.R.B. 2018).

But this 'eyeball econometrics' has its limitations and the second approach is to apply standard econometric methods to assess the stability of these ratios. The applicable econometric concept is *time series stationarity* and the associated unit root testing procedure whose general principles were introduced in section 3.1.2.

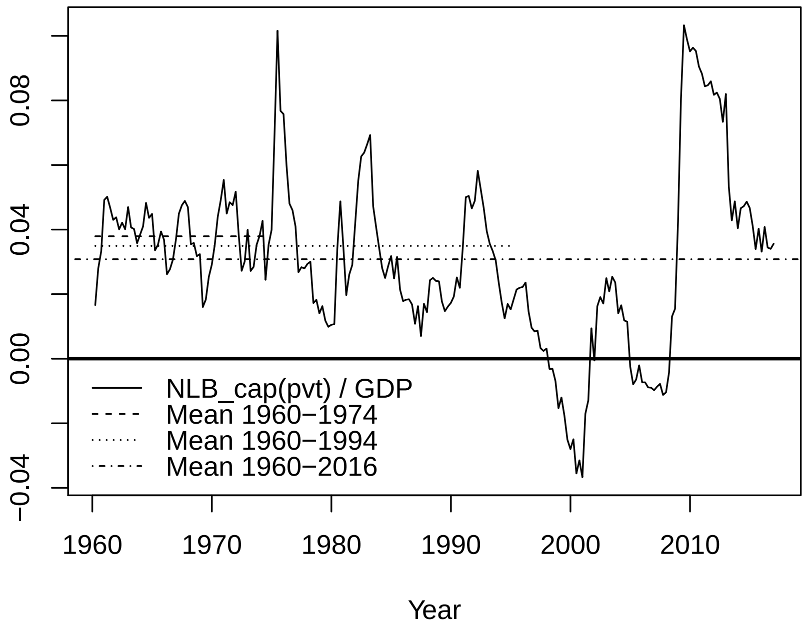

Figure 4.2.1: US Private Sector Balance relative to GDP

Data:

Source: US IMA

NLB Cap A/c (pvt) (A:31)

Gross Domestic Product (A:1)

('A:' refers to the line number in table 3.2.8)

One of the drivers of the New Cambridge hypothesis was the empirical observation that the UK private sector balance had been small and stable over recent decades, and furthermore, that the same applied to the US. Figure 4.2.1 shows the private sector balance for the US from 1960-2016. In the period up to the mid-1970s (which coincides with the period that the New Cambridge group were writing about), it did appear to be 'mean-stationary' though quite volatile. The short horizontal dotted line shows the mean value in this period, (3.79%). From the mid-1970s to the mid-1990s, it could be said that the series is still close to mean-stationary (but with a slight downtrend), but much more volatile. The mid-length horizontal line shows the mean value for the period up to the mid 1990s, (3.49%). The extension to this second period has lowered the private sector surplus by nearly 0.5%, meaning that, in addition to the uncertainty that the volatility brings, US citizens were on average poorer in this period. Finally, bringing in the period from the mid-1990s to 2016, any suggestion of a 'small and stable balance' seems preposterous, traversing as it does the dotcom bubble, the global financial crisis and the post-crisis period. The longer dotted line shows the lower mean value for the whole period (3.08%), showing a further reduction in private sector wealth.

This plot could also partly explain why macroeconomic analysis based on the idea of a stationary private balance went out of favour; the increasing instability from the mid-1970s onwards culminating in the wild swings of the dotcom bubble and the GFC compromised the whole approach. The plot does however suggest that in the post-crisis period, balances may finally be returning to sustainable levels.

4.2.1 Stock-Flow Ratios for a Three Sector Economy

This section deals with the norms relevant to the three-sector SFC model to be developed in chapter 6. It is based on the three balances relation of the 'New Cambridge school', introduced in section 2.1.2. Taking the approach of starting out with a highly aggregated model, and eventually adding detail by disaggregating as the analysis proceeds, stocks of financial assets for each sector will initially be aggregated into a single figure — net financial assets — whose sum will be zero across the three sectors, since an asset of one sector is necessarily a liability of another, and vice versa. A balance sheet generally consists of two types of stocks — financial and non-financial. For the highly aggregated three sector economy, non-financial assets are initially deemed to be 'internal' to each sector and it is the financial assets and liabilities that are the determinant of the dynamics of the model. This is due to the fact that imbalances between the sectors will lead to inter-sectoral financial flows, and the extent of these flows depends on the willingness of each sector to hold obligations issued by the others. So there is a financial assets-income ratio for each sector even if, for historical or practical reasons, it takes a slightly different form for each sector. For the private sector, the *wealth-income ratio* relates net financial assets to private disposable income, for the public sector, the ratio of government debt to GDP is widely used but one could equally relate public sector debt to the government share of national income; for the foreign sector, the financial stock is the *International Investment Position* which is a measure of the net claims of the domestic economy on the rest of the world. A wealth-income ratio can be formed from this by relating it to GDP or the flow of exports.

There is always a choice of measures for these ratios and these will be investigated for each sector in the sections that follow.

4.2.1.1 The Private Sector Wealth-Income Ratio

In a three sector model, the private sector is the aggregate of households, firms and the financial sector. Aggregating over these three sectors means that financial claims between the sectors become 'internal', for example, debt held by the financial sector against firms and households, as well as most equities and corporate bonds all net out during the aggregation. What remains is claims on and obligations to the other two sectors, mostly holdings of government debt and net foreign reserves against the rest of the world.

As a matter of empirical observation, the New Cambridge group, working in the 1970s, perceived that the private sector in the UK had been running a 'small but stable balance' in recent decades, so they were continuously acquiring financial assets at the expense of the other two. If the size of the balance was roughly similar to the growth rate of income, they could infer that private sector holdings of financial assets must be in a stable ratio to private disposable income, in other words that the wealth-income ratio constituted a stable norm,

$$\alpha = \frac{NFA_P}{YD_P} \tag{4.2}$$

where NFA_P is the stock of financial assets of the private sector, YD_P is private disposable income and α is the wealth-income norm for the private sector. To investigate this hypothesis, and to see whether it holds more generally than just for the UK economy in the 1970s, various wealth-income ratios are calculated from the data series of the Integrated Macroeconomic Accounts (IMA) of the United States between 1960 and 2016.

The first issue is to select which measures of wealth should be used. The measure of income will always be private sector disposable income (YD_P, table 3.2.8, line 9) but there is a wider choice of wealth measure. Some candidate measures of private financial assets are considered in subsequent sections, each of which deals with revaluation effects in different ways; firstly, net financial assets is directly computed from the balance sheet by subtracting total liabilities from total assets in the US IMA, secondly, the values of private sector net lending and borrowing from the financial account and from the capital account are accumulated over the time period, and thirdly, a measure of the accumulated NLB which is already provided in the IMA balance sheet.

The second issue is the question of 'real' or 'nominal' values. When quantifying stocks, there is always an issue of how to deal with revaluation effects. Flows are normally measured during a single period and are normally stated in current prices. It is only when comparing flows from one period with those of another that adjustment using deflators or price indices is required. But stocks accumulate across periods, a loan advanced in 2012 may be added to an existing debt denominated in 2010 dollars and finally repaid in 2015 dollars. Most financial assets are implicitly 'converted' at the beginning of each period to the currency unit of the new period at par. This could be termed 'the changing unit of measure' issue. But even if a constant unit of measure were possible, there would be changes in the market-prices of financial wealth; financial assets are often revalued over time due to changes in interest rates and market perceptions of risk and reward following changes in economic conditions or investor expectations. In the national income accounts, the flow of funds (changes in stocks) are reported in two steps, 'volume changes' i.e the surplus/deficit on the financial account and the capital account (which should be equal), and revaluation effects which capture the changes in values of assets.

> What Godley used to do in his applied work was to avoid market-price measures of wealth, and use instead a "historic price" measure obtained by cumulating the relevant flow over time. For households, this would be net borrowing/lending, cumulated so as to match an available measure of the stock in a base year. This measure would not suffer from volatility in the stock market or the housing

market[3].

A recently published working paper "On the Design of Empirical SFC Models" (Zezza & Zezza 2019) deals with this question. Specifically, for the accumulation of net financial assets they offer the following equation,

$$NFA_t = NFA_{t-1} + NL_t + NKG_t \tag{4.3}$$

where NFA_t is Net Financial Assets, $NL - t$ is net lending and NKG_t is Net Capital Gains all at time t, all in current prices. There are two ways of measuring $NL - t$, through the capital account or the financial account; they will be different leading to a 'statistical discrepancy' and a need to reconcile the two, what they call 'squaring the matrix',

> ...two possible strategies may be adopted: (a) we can close the accounting identities by adding appropriate variables for discrepancies, which will usually be left as exogenous unexplained variables, or (b) we could allocate the discrepancy to one or more variables. The pros of the former strategy are that model variables will exactly match the data, while the cons are that the number of model variables will quickly increase. The cons of the latter strategy will be that model variables only approximate the data (Zezza & Zezza 2019, p.9).

NKG_t in equation 4.2.1.1 could be calculated from the current prices of financial assets and liabilities once NL_t is known or, by using Godley's method described above, a value for accumulated net capital gains up to time t (the index year) is being applied to the accumulated values of NL_t to get NFA_t. These should

[3]Private communication, Gennaro Zezza, 22 Feb 2017.

lead to equivalent results at time t.

This study will follow method (a) for the calculation of NLB in chapter 6. For the stocks of net financial assets to be used in the next sections, the values in sections 4.2.1.1(a) and 4.2.1.1(c) use time series from the US IMA at current prices while section 4.2.1.1(b) uses Godley's accumulation method.

The use of nominal values (current prices) for both the stock and the flow is justified in three ways; firstly, deflating stocks of financial assets and liabilities does not result in a 'real' value by separating out volume and price effects as in income and expenditure flows, or of non-financial capital. It's useful to separate volume growth from revaluation effects but the value of the stock will still be the sum of the two. Godley's method above may eliminate the volatility of capital gains element but will only coincide with the 'actual' value in the index year.

Secondly, if the stock and the flow are deflated with the same deflator, their ratio will not be affected. Different deflators for the stock and the flow could be applied, since inflation will affect flows differently from stocks which incorporate accumulated revaluation effects from previous years, while the flow is a single value from the current year. But if they are deflated to the same base year, the ratio will be the same as that using current prices in the same year.

Thirdly, experience with the econometric estimation of the New Cambridge private expenditure function led to the conclusion that nominal values should be used,

> Whatever the appropriate level of disaggregation, the relationship between private expenditure and income, when derived from a

> hypothesis about the stock of financial assets relative to income, must be expressed in money or current price terms, not in 'real' terms (Cripps & Godley 1976, p.49).

Earlier versions of the equation were expressed in ‘real’ terms but didn’t cope well with the high inflation of the mid-1970s so they switched to current prices and there’s some justification for this in the paper.

This discussion of nominal/real values has been focussed on the stock of net financial assets and the flow of private disposable income for the next sections on stock-flow norms, but it is also relevant to the models in chapter 6 which involve time series for the flows of income and expenditure, including private disposable income. Nominal values are also used there by appeal to the findings in Cripps & Godley (1976).

4.2.1.1(a) Net Financial Assets (NFA_P)

The first and simplest option is to take the net financial assets of the private sector from the IMA balance sheet (table 3.2.4, line10). This measure includes accumulated revaluation of assets and liabilities. Figure 4.2.2 shows that this ratio exhibits some of the features of a norm in the period up to the global financial crisis, that is, a pattern of minor deviations and corrections though not around a constant value but a gradually declining trend. There is a clear break in the period following the dotcom bubble, with a rapid rise in the ratio, returning to the levels of the 1960s over the space of a decade. In the econometric tests on this time series, it will be broken into two sub-series, divided at the breakpoint at 2003$Q$4. In the same communication as that in footnote 3, Zezza comments on this plot “[this is] a ratio of market-price

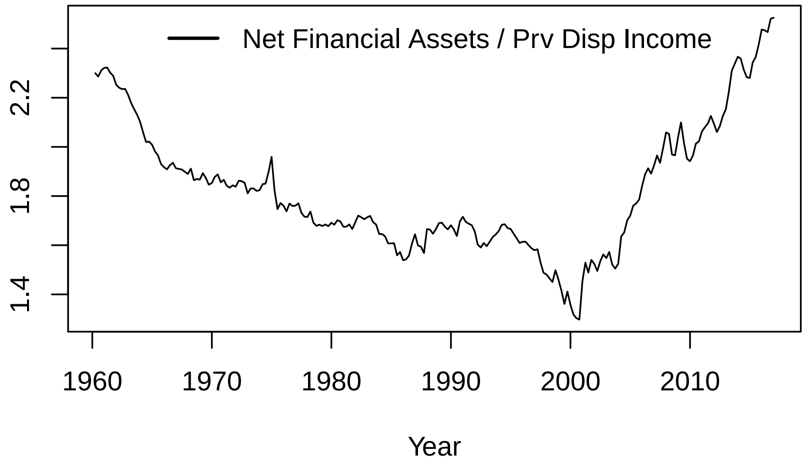

Figure 4.2.2: Private Sector Net Financial Assets

Source: US IMA
Net Financial Assets(pvt) (C:10)
Private Disposable Income (A:9)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Ratio of Nominal Values.

financial wealth to income [...], there were huge variations in market prices in the two 1990 and 2000 bubbles, and possibly the trend [...] may be due to a trend in the price of financial assets relative to a proper deflator for personal income".

The econometric test to be applied to this ratio consists of a unit root test for stationarity.

In the first period, the ADF test indicates that NFA_P and YD_P are I(1) but not I(2) and this is confirmed by the KPSS test. For the ratios, NFA_P/YD_P and $log(NFA_P/YD_P)$, the ADF test rejects the null hypothesis of a unit root (at the 5% and 10% levels respectively), but the KPSS test strongly rejects the null of stationarity. The tests give conflicting results and not in the expected way — the ADF test has been criticised for failing to reject the null hypothesis of a unit root when there isn't one, but here it *has* rejected the null, but the

		1960 - 2003		2004 - 2016	
Variable	Series	ADF Test	KPSS Test	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity	Unit Root	Stationarity
NFA_p	Level	accept	reject***	accept	reject*
	Difference	reject***	accept	accept	reject*
	Dbl Difference	reject***	accept	reject**	accept
PDY	Level	accept	reject***	accept	accept
	Difference	reject**	accept	accept	accept
	Dbl Difference	reject***	accept	reject***	accept
NFA_p/PDY	Level	reject*	reject**	accept	accept
	Difference	reject***	accept	accept	reject*
	Dbl Difference	reject***	accept	reject***	reject*
$log(NFA_p/PDY)$	Level	reject*	reject**	accept	accept
	Difference	reject***	accept	accept	reject*
	Dbl Difference	reject***	accept	reject***	reject*

Table 4.2.1: Unit root tests for the private net financial assets - income ratio

Source: US IMA
Net Financial Assets(pvt) (C:10)
Private Disposable Income (A:9)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

KPSS test has rejected stationarity. The Phillips-Perron test (Phillips & Perron 1988) is deployed to break the deadlock, it fails to reject the null hypothesis of a unit root, so it can be concluded that both ratios are non-stationary.

In the second period, the ADF test implies that all series are I(2). The KPSS test implies the opposite, that they are all stationary, with the exception of NFA_P.

In conclusion, it seems that the ratio of private sector net Ffnancial assets to private disposable income is not going to fill the role of a stock-flow norm. Other candidates for the private sector wealth-income norm will be examined below.

4.2.1.1(b) Cumulative NLB

Following Godley's recommended approach to accumulating stocks of financial assets cited above (page 186) leads to a ratio formed from the accumulated private sector net lending/borrowing figure from the US IMA over the period. There is a choice of two time series for net lending/borrowing — that from the financial account or that from the capital account. Both are plotted in figure 4.2.3. The gap between the two time series is the statistical discrepancy (table 3.2.8, line 12). Of the two, NLB on the financial account seems closer to being 'mean-stationary', although it displays large and long-lived departures from its mean value.

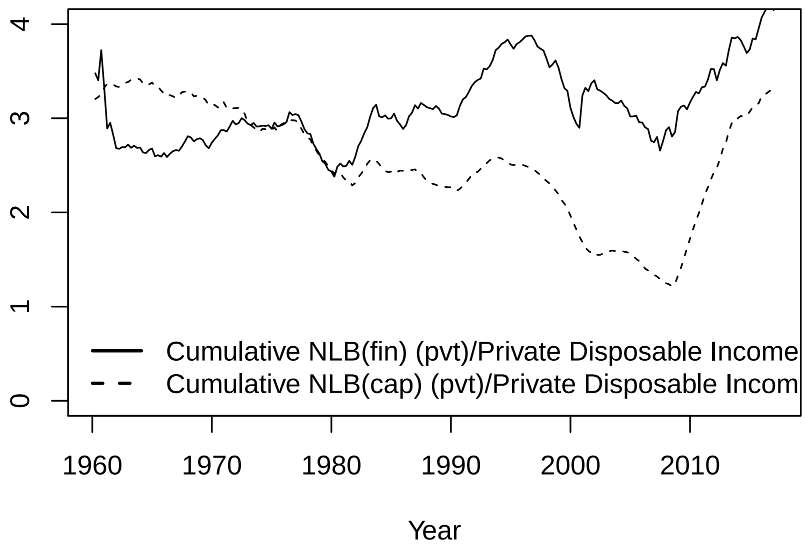

Figure 4.2.3: Comparing Wealth Income Ratios: Cumulative NLB(cap) and NLB(fin)

Source: US IMA
Cumulative NLB(fin) (pvt) (C:26)
Cumulative NLB(cap) (pvt) (C:27)
('C:' refers to the line number in table 3.2.4)

The analysis of the previous section will be repeated to assess stationarity of the two time series. Table 4.2.2 reports the results of unit root tests on these time series for two periods, the first up to a breakpoint in 1998$Q3$, the second for the whole sample period; as before an ADF test, whose null hypothesis is

Variable	Series	1960$Q$1 : 1998$Q$3 ADF Test	KPSS Test	1960$Q$1 : 2016$Q$4 ADF Test	KPSS Test
	Null Hypothesis	Unit Root	Stationarity	Unit Root	Stationarity
$\Sigma NLB(fin)_P$	Level	accept	reject***	accept	reject***
	Difference	accept	accept	reject**	reject*
	Dbl Difference	reject***	accept	reject***	accept
$\Sigma NLB(cap)_P$	Level	accept	reject***	accept	reject**
	Difference	accept	accept	accept	reject**
	Dbl Difference	reject***	accept	reject***	accept
YD_P	Level	accept	reject***	accept	reject***
	Difference	reject***	accept	reject***	accept
	Dbl Difference	reject***	accept	reject***	accept
$\Sigma NLB(fin)_P/YD_P$	Level	accept	reject**	accept	accept
	Difference	reject***	accept	reject***	accept
	Dbl Difference	reject***	accept	reject***	accept
$\Sigma NLB(cap)_P/YD_P$	Level	accept	reject**	accept	reject**
	Difference	reject**	accept	reject*	reject*
	Dbl Difference	reject***	accept	reject***	accept

Table 4.2.2: Unit root tests for accumulated NLB(fin) and accumulated NLB(cap)

Source: US IMA
Cumulative NLB(fin) (pvt) (C:26)
Cumulative NLB(cap) (pvt) (C:27)
Private Disposable Income (A:9)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

the presence of a unit root, and a KPSS test whose null hypothesis is that the series is stationary will be reported.

In the first period, the results are as expected for the KPSS test, it rejects stationarity of all series in levels but finds the differenced series to be stationary suggesting that all series, including the stock-flow ratios, are I(1). The ADF test also finds a unit root in the levels of all time series and rejects the unit root in the differenced data, except for the cumulative NLB(fin) and NLB(cap) where a unit root is detected in the differenced data, suggesting that these series might be I(2).

For the full period, both the ADF test and the KPSS test agree that cumulative

NLB(fin) and NLB(cap) are I(2), and that private disposable income is I(1), but disagree on the stock-flow ratios, the ADF says they are I(1), the KPSS says that $\Sigma NLB(fin)_P/YD_P$ is stationary and that $\Sigma NLB(cap)_P/YD_P$ is I(2).

The reason for this disagreement concerning the ratios may be better understood from the scatter plot in figure 4.2.4, taking $\Sigma NLB(fin)_P/YD_P$ as an example, with the stock on the y-axis against the flow on the x-axis for the period 1960 - 2016. In such a plot, the wealth-income ratio is the slope of any line from the origin to a point in the space.

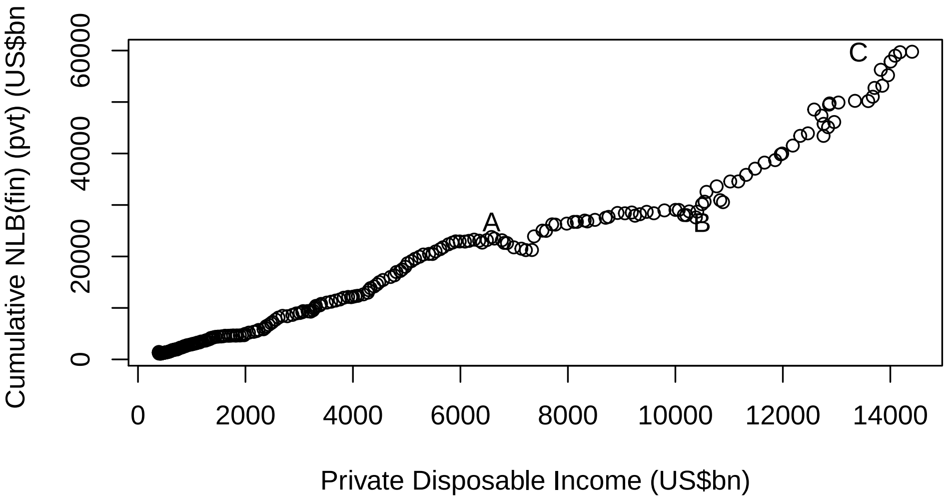

Figure 4.2.4: Scatter plot of Wealth and Income (1960 - 2016)

Source: US IMA
Cumulative NLB(fin) (pvt) (C:26)
Private Disposable Income (A:9)
('A:' refers to the line number in table 3.2.8)

The plot shows three distinct phases, in the first, up to point A which corresponds to 1998Q3, cumulative NLB is rising roughly in line with income; between A and B which corresponds to 2007Q4, the plot is flat — cumulative NLB is roughly constant despite the fact that income is continuing to rise. In the post-crisis period (BC), a rising trend resumes although with a steeper rate than that in period OA.

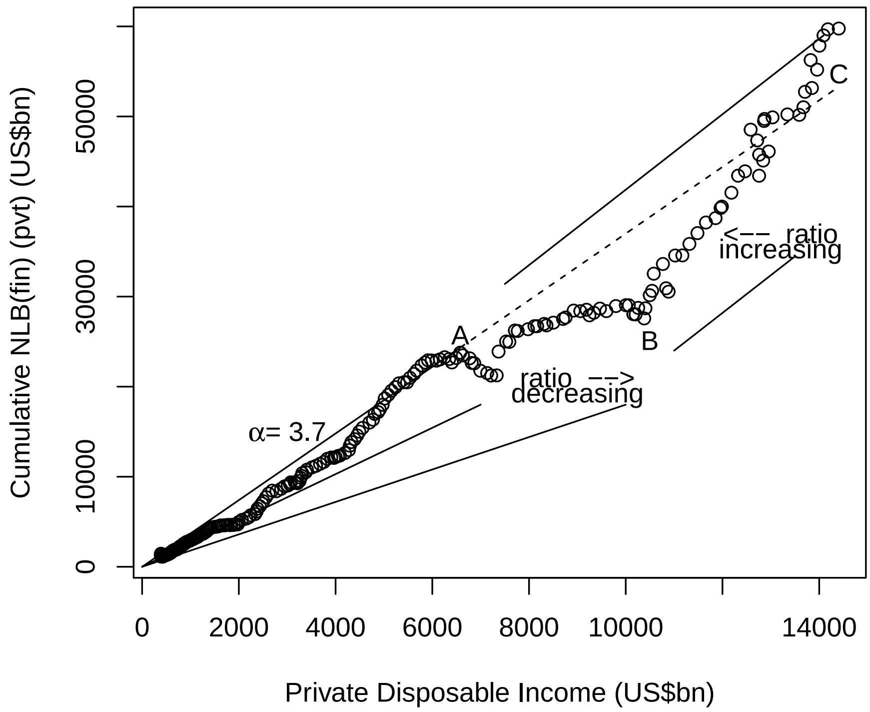

Figure 4.2.5: Changing values of the Wealth-Income Ratio in the Wealth-Income Scatterplot of figure 4.2.4

Source: US IMA
Cumulative NLB(fin) (pvt) (C:26)
Private Disposable Income (A:9)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)

The plot is transferred to figure 4.2.5 to show what is happening to the ratios. In the period OA when the stock is rising roughly in line with income, the ratio is not quite constant but gradually rising, reaching a maximum value of 3.7 as marked by the solid line OA in 1998Q3.

The segment AB corresponds to a period of declining ratios since the accumulated NLB is roughly constant and income continues to rise — lines from the origin to the points in this range have progressively decreasing slope. This corresponds to the large decline between 1998Q3 and 2007Q4 in figure 4.2.3.

This is the inter-crisis period, in which the private sector is running a stable, virtually zero balance (i.e. $S - I \approx 0$) corresponding to a period of low overall sectoral saving (S), and high investment (I) during the housing bubble.

In period BC, which corresponds to the post-crisis period, the wealth-income ratio rises again, possibly to return to its previous trend marked by the dotted line extension of line OA.

A similar graphical analysis of the stock-flow ratio derived from cumulative NLB on the capital account with private disposable income would yield similar results, although with greater volatility.

In conclusion, the data does not provide convincing evidence for a stock-flow norm based on the ratio of cumulative NLB on the financial account as the stock and private dispsoable income as the flow because of rejection of stationarity in the unit root tests and its volatility in the period since 1990.

4.2.1.1(c) The NLB Stock

The cumulative NLB on the financial account used in the previous section was accumulated directly from the NLB(fin) account from the IMA, however there is a cumulative NLB stock time series provided 'ready-made' in the balance sheet of the IMA (table 3.2.8, line 42). This differs slightly from the 'home-made' version in section 4.2.1.1(b) above, so will be investigated here. It will be referred to as 'NLB stock' to distinguish it from the previous series.

The stock-flow ratio formed by dividing it by private disposable income is plotted in figure 4.2.6. It does display some 'norm-like' characteristics in its oscillatory behaviour but the oscillation is about a trend line rather than a mean-stationary value. The trend line descends from the 1960s to the mid-80s then rises steadily until the peak of the dotcom bubble. It responds rapidly to the financial crises but appears to be resuming its previous trajectory in the most recent period.

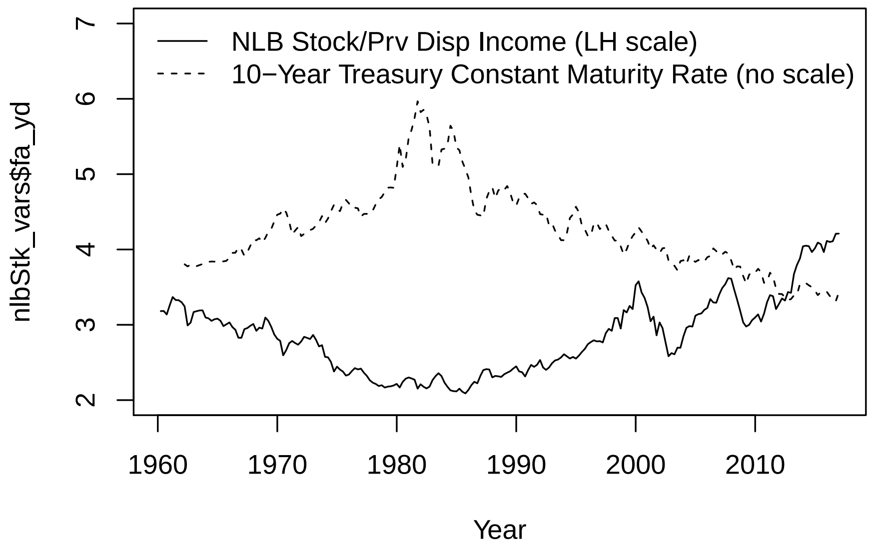

Figure 4.2.6: A Wealth-Income Ratio from NLB stock vs PDY

Data:

1. *Source: US IMA*
   NLB Stock/Prv Disp Income (C:11)
   ('C:' refers to the line number in table 3.2.4)
2. 10-Year Treasury Constant Maturity Interest Rate (percent, not seasonally adjusted) .
   FRED (2018, Table DGS10)

Table 4.2.3 shows the results of the unit root tests for the scenario of the descending trend to the mid-1980s followed by a rising trend, with the addition of a single test for the entire period.

As with the ratio in the previous section, the results here are inconclusive. To support the hypothesis of a stable stock-flow norm, the ratio should be a stationary time series. In the first period, the ratio is declining but appears to be stationary around a declining deterministic trend. The ADF test in this period rejects the null hypothesis of a unit root at the 10% level making it reasonable to infer that the series is stationary. This is supported by the KPSS

Period	Series	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
1960Q1:1985Q3	Level	reject*	accept
	Difference	reject***	accept
	Dbl Difference	reject***	accept
1985Q4:2016Q4	Level	accept	accept
	Difference	reject**	accept
	Dbl Difference	reject***	accept
1960Q1:2016Q4	Level	accept	reject***
	Difference	reject***	accept
	Dbl Difference	reject***	accept

Table 4.2.3: Unit root tests for stock-flow ratio based on NLB stock

Source: US IMA
NLB Stock(pvt) (A:42)
Private Disposable Income (A:9)
('A:' refers to the line number in table 3.2.8)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

test which fails to reject the null hypothesis of stationarity. However in the second period, from the mid-1980s onwards, perhaps confounded by the large perturbations of the dotcom and housing bubbles, the results are mixed. The ADF test fails to reject the null hypothesis of a unit root suggesting that the series is non-stationary, but the KPSS test fails to reject the null hypothesis of stationarity, so again, the two tests are at odds with each other. Looking at the whole period together without regard for breakpoints in the data, both tests agree that the series is non-stationary.

Since the ADF and the KPSS tests both concur that the ratio could be stationary for the NLB stock measure of financial assets, the hypothesis of a stationary ratio, and hence a stable stock-flow norm, will be retained at least until the next stage of the investigation, meaning that this ratio will be used as the private sector wealth-income norm in the three sector stock-flow model of chapter 6.

The Stock-Flow Norm and the Long-Term Interest Rate

Superimposed on the plot in figure 4.2.6 is the 10-Year Treasury Constant Maturity Interest Rate (nominal %p.a.) (FRED 2018, Table DGS10) which has been scaled to fit into the frame of the plot. The scale is not shown because it is the *shape* of the plot that is of interest not its magnitude but, for reference, the starting value in 1962Q1 is 4.02%, the peak in 1981Q3 is 14.84% and the value in 2016Q4 is 2.14%. There appears to be an inverse correlation between the ratio and the long-term rate and, although the dotcom bubble and the GFC are major deviations from the trend, the ratio appears to be returning to trend in the post-crisis period. If indeed there is a long-term relationship between the wealth-income ratio and the long-term rate of interest, it should manifest itself as a cointegration relation between these two time series, and this is investigated in figure 4.2.7.

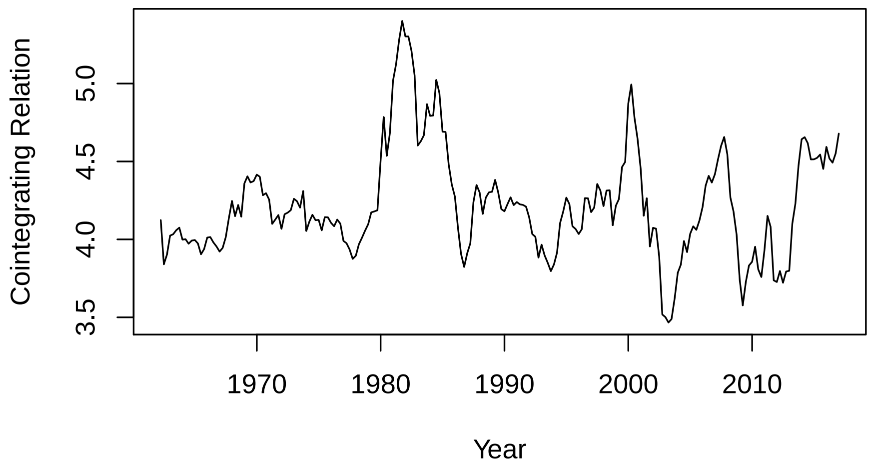

Figure 4.2.7: The Cointegration Relation between the Wealth-Income Ratio NLB stock / Private Disposable Income and the 10-yr interest rate.

Data:
1. *Source: US IMA*
NLB Stock/Prv Disp Income (C:11)
('C:' refers to the line number in table 3.2.4)
Data: Ratios of Nominal Values.
2. 10-Year Treasury Constant Maturity Interest Rate (percent, not seasonally adjusted) .
FRED (2018, Table DGS10)

The plot suggests that there is a long-run relationship between this wealth-income ratio and the long-term rate of interest which has all the appearances of being mean-stationary, albeit with large deviations from the mean during the 1980s (the Volker years), and the dotcom and housing bubbles.

Summary: The Private Sector Wealth-Income Norm This section set out to examine three candidate stock-flow ratios to see whether they are sufficiently stable to qualify as *norms*; visual inspection of time series plots and stationarity tests were the principal means of making this assessment. The wealth measures considered were, net financial assets of the private sector (defined in table 3.2.4, line 10), the cumulated NLB for the private sector (defined in table 3.2.4, line 26) and an alternative measure of the cumulated NLB taken directly from the US IMA balance sheet (defined in table 3.2.4, line 42). These measures of wealth were in all cases combined with private disposable income to form a wealth-income ratio.

The first ratio, formed from private sector net financial assets, was plotted in figure 4.2.2 and displayed the mean-reverting behaviour expected of a norm, but around a steadily declining trend rather than a stable mean. This trend ended abruptly in the mid-2000s to be replaced by a steep up-trend with the result that it returned to its 1960 level in the space of a single decade. It's conceivable that stock-flow norms could be trend stationary, not necessarily mean-stationary, so this ratio was tested in two phases split at the breakpoint in 2003Q4. However the results were confused with the ADF test weakly rejecting the unit root and the KPSS test strongly rejecting stationarity in this first period.

The second ratio, formed by accumulating the NLB values for the private sector over the period, which was Godley's preferred method (see footnote p.187), comes in two varieties depending on whether the capital account or the financial account is accumulated. The financial account appeared from visual inspection to be closer to a stationary series despite very high volatility, however unit root test showed these time series to be I(2) in this range and the corresponding stock-flow ratios to be non-stationary.

The third ratio, was also an accumulation of values of the private sector NLB from the financial account provided as part of the dataset from the FRB. It showed a similar pattern to the first ratio,based on net financial assets, oscillating around a declining trend up until the mid-1980s, then rising until the present time. This pattern inversely mirrors the long-term interest rate as shown in figure 4.2.6. Unit root tests on this ratio up to the breakpoint in the mid-1980s showed weak support for stationarity from both the ADF and the KPSS tests, so this ratio will be used henceforth as the private sector wealth-income ratio.

In conclusion, it is evident that there is no long-term stable, private sector wealth-income ratio that endures the changes to the economy that have taken place over the time range of this study. The original empirical observation that gave rise to the notion of a stock-flow norm was the "small and stable private sector balance" of the 1960s and 1970s in the UK. Figure 4.2.1 shows a similar phenomenon in the US at that time, but the enormous volatility that has been observed since the mid-1970s has meant that 'norm-like' behaviour may be observed in certain periods, but tends not to endure.

The other observation from this section is that the ratios tend to be trending rather than mean-stationary. Figures 4.2.6 and 4.2.7 point to one possible cause of this trending behaviour, the long-term interest rate.

4.2.1.2 The Public Sector Wealth-Income Ratio

The previous section investigated three candidate ratios for the stock-flow norm for the private sector in a three sector SFC model. This section will turn to the public sector and examine candidates for the financial stock-flow norm. The analysis will follow the same pattern established in the previous sections for the private sector wealth-income norm, namely the time series for each candidate ratio will be plotted and then unit root tests conducted to assess stationarity.

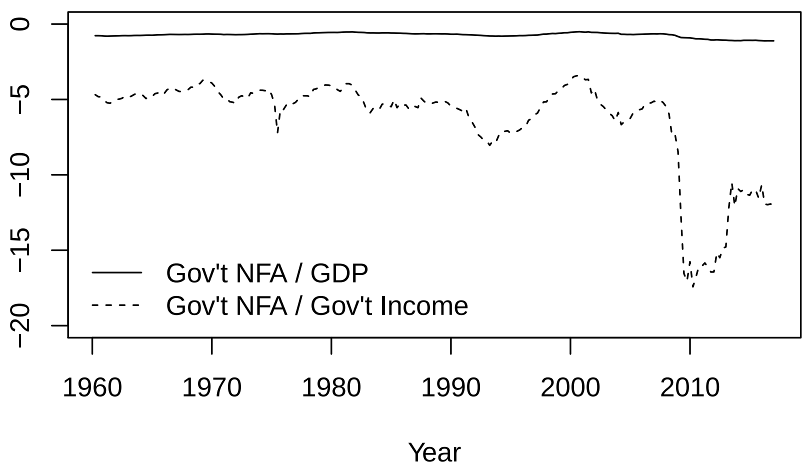

Figure 4.2.8: Government NFA-Income Ratios

Source: US IMA
Net Financial Assets(gov) (C:12)
Government Income (A:8)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Ratios of Nominal Values.

There are two principal candidates for the stock variable — public sector net financial assets (defined in table 3.2.4, line 12) and total public sector liabilities (government debt) — and equally, two candidates for the flow variable — GDP and government income, which is total tax revenue plus net transfers. In the case of the public sector, the figure for net financial assets is the same as the value of the accumulated NLB on the financial account in the IMA balance sheet. Since this was the stock variable that most closely approximated a stock-flow norm for the private sector in the previous section, it will be investigated in the sections below with each of GDP and gov't income as flow variables. Repeating the analysis with total liabilities as the stock variable was not found to be an improvement over NFA and is therefore not reported.

Figure 4.2.8 gives a comparative plot of the two ratios formed from public sector net financial assets. Plotting both ratios on the same scale for comparison is both informative and misleading — it shows that government income is much more volatile than GDP and that it collapsed much more than GDP following the crisis, but this makes the government net financial assets to GDP ratio look stationary by comparison, which is actually misleading. These two ratios will be assessed separately below.

4.2.1.2(a) Public Sector Net Financial Assets to GDP

The public sector net financial assets to GDP ratio is shown in figure 4.2.9 showing that it has also been rather volatile, reaching -100% in the immediate post-crisis period.

To assess whether the ratio is a stationary time series, the ADF and KPSS tests were applied as before, the results are given in table 4.2.1.2(a). The series was cut into three sub-periods, the first up to 1980$Q4$ which is the gently rising part of the series, the second was from the start to the start of the GFC, 1960$Q1$ to 2007$Q2$ and the third covered the whole period.

In the first period, the ADF test rejects the unit root at the 5% level and the

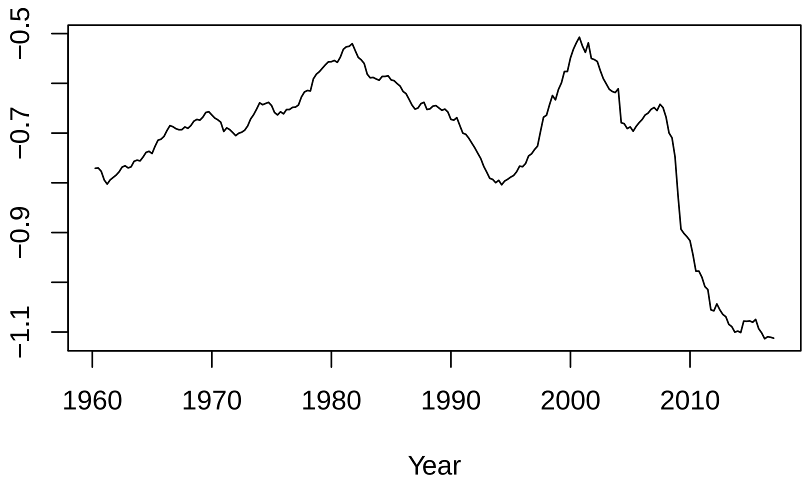

Figure 4.2.9: Government Net Financial Assets - GDP Ratio

Source: US IMA
Net Financial Assets(gov) (C:12)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Ratios of Nominal Values.

KPSS test indicates stationarity, so there could be a brief period of a stable stock-flow norm in the public sector. In the second period, the ADF again rejects the unit root but the KPSS test rejects stationarity so the result is inconclusive. In the final test for the period as a whole, both tests agree that the series is non-stationary.

Period	Series	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
1960$Q$1 to 1980$Q$4	Level	accept	accept
	Difference	reject**	accept
	Dbl Difference	reject**	accept
1960$Q$1 to 2007$Q$2	Level	reject*	reject*
	Difference	reject**	accept
	Dbl Difference	reject***	accept
1960$Q$1 to 2016$Q$4	Level	accept	reject***
	Difference	reject***	accept
	Dbl Difference	reject***	accept

Table 4.2.4: Unit root tests for stock-flow ratio based on Government Net Financial Assets to GDP

Source: US IMA
Net Financial Assets(gov) (C:12)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

4.2.1.2(b) Public Sector Net Financial Assets to Government Income Ratio

The ratio of public sector net financial assets to government income is shown in figure 4.2.10. By contrast with the government net financial assets to GDP ratio in the previous section, it gives the impression of stationary behaviour up until the eve of the financial crisis, after which the combination of a collapse in government income and the expansion of government liabilities in the post-crisis period has caused the series to depart completely from its previous trajectory.

Applying the usual unit root tests to assess stationarity of the ratio led to the results in table 4.2.1.2(b). As expected, both tests find against the hypothesis of stationarity of the ratio for the time series covering the full period, however in the pre-crisis period, the ADF test rejects the null hypothesis of a unit root while the KPSS test fails to reject stationarity, so both tests agree that the series is stationary in this period, so we could conclude that this ratio acts as a

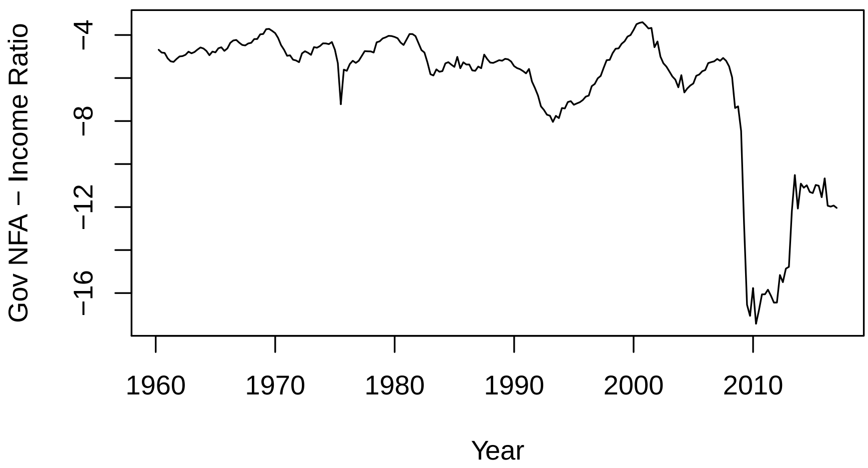

Figure 4.2.10: Government Net Financial Assets - Government Income Ratio

Source: US IMA
Net Financial Assets(gov) (C:12)
Government Income (A:8)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Data: Ratios of Nominal Values.

stable norm for the public sector.

Summary: Public Sector Stock-Flow Ratio This section set out to examine two candidate stock-flow ratios in the public sector to see whether they are sufficiently stable to qualify as *norms*; a single stock was considered, net financial assets of the public sector, and two flows, GDP and net government income which is total tax revenue plus net transfers.

The first ratio, plotted in figure 4.2.9, has the appearance of being stationary around rising or falling trends in the pre-crisis period, and then collapsing in the post-crisis period. It's conceivable that stock-flow norms could be trend stationary, not necessarily mean-stationary, so this ratio was tested in three phases, the first up to a breakpoint in 1980$Q4$, the second from the start to 2007$Q2$ and the third covering the whole period. The two test types agree on stationarity for the first interval and non-stationarity for the enitire period, but

Period	Series	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
1960Q1-2007Q2	Level	reject*	accept
	Difference	reject***	accept
	Dbl Difference	reject***	accept
1960Q1-2016Q4	Level	accept	reject**
	Difference	reject***	accept
	Dbl Difference	reject***	accept

Table 4.2.5: Unit root tests for stock-flow ratio based on government NFA to Government Income

Source: US IMA
Net Financial Assets(gov) (C:12)
Government Income (A:8)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

differed on the second period, so this ratio could constitute a stock-flow norm in the period up to the crisis.

The second ratio used the same stock but government income instead of GDP for the flow. Figure 4.2.10 showed the effect of the collapse in government income at the time of the crisis, which has still not recovered. Nevertheless, the ratio appeared relatively stable in the pre.crisis period, and the unit root tests confirmed this assessment, so this ratio could also qualify as a norm in this period.

The conclusions are similar to those stated above for the private sector, stocks and flows do seem to form stable ratios in the public sector also, but for limited periods. The government's income is vulnerable during downturns and so the stability is regularly broken.

4.2.1.3 The Foreign Sector Wealth-Income Ratio

This section looks to the foreign sector to see if there is evidence of a stable balancing relationship for the US between foreign net assets and income, similar to those postulated for the other sectors.

Over the period of this study, US exports have followed a steady compounded annual rate of growth, similar to that of most of the time series in this study, but net foreign assets has not. The time series that will be used in this model is being referred to as FR, for 'foreign reserves' but is actually the International Investment Position (IIP) of the United States and it has followed a different trajectory as figure 4.2.11 shows. It currently stands at a deficit of around US$ 8 trillion, and seems to have progressed through three phases in getting there; in the first, in the period up to the early 1980s (point A in the figure), it appears to be following the 'normal' growth pattern, in the second, from the early 1980s to the global financial crisis (segment AB in the figure), it suddenly changed its trajectory and entered a steady decline; the third phase is the post-crisis period when the drop has been vertiginous.

The best candidate for a foreign sector stock-flow ratio based on the IIP would be net foreign assets to national income, since income is the corresponding flow that would most determine net foreign assets, being the major determinant of imports, but net foreign assets to exports could also be considered. These are compared in figure 4.2.12. The time series used for the IIP is the accumulated NLB for the foreign sector taken from the US IMA (table 3.2.8 (A:44)).

The two follow almost identical patterns at different scales; the phases identified in the plot of IIP are reproduced here, and seem to fit well. The comparison

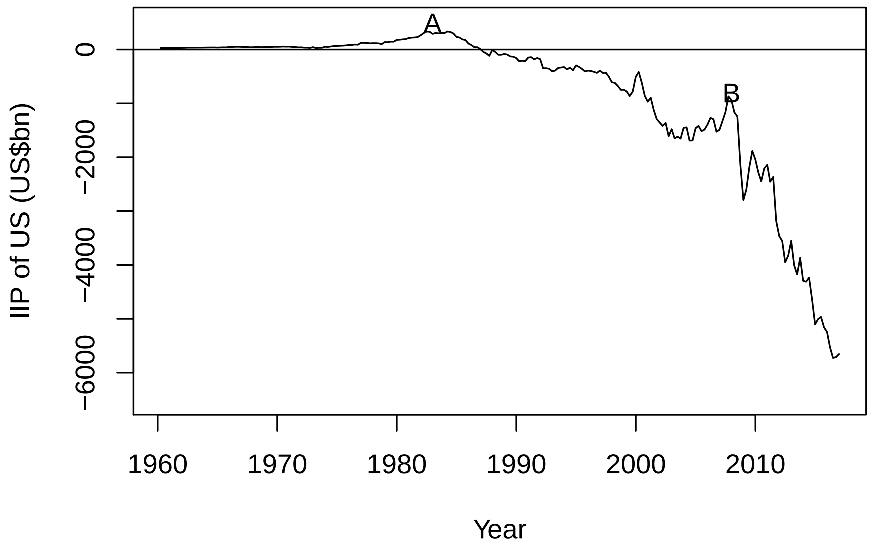

Figure 4.2.11: US International Investment Position

Source: US IMA
NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)

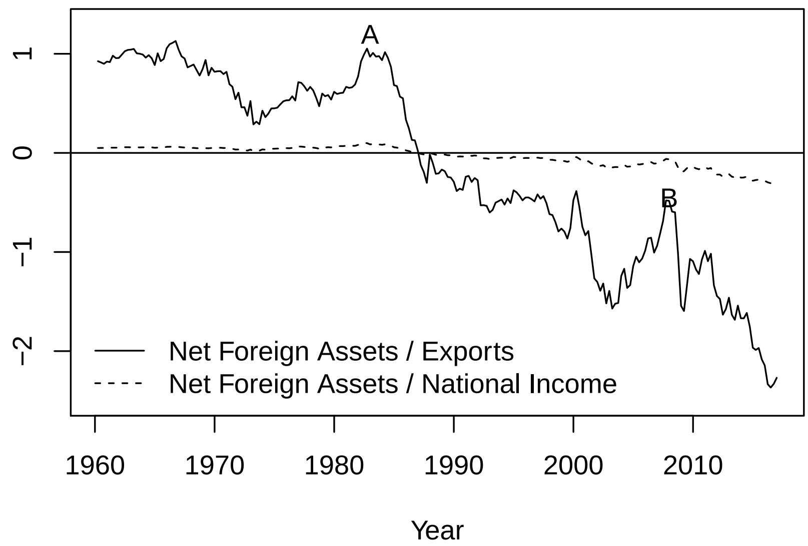

Figure 4.2.12: US Foreign Sector Stock-Flow Ratios

Source: US IMA
NLB Stock(RoW) (A:44)
Gross Domestic Product (A:1)
Total Exports (C:7)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)

shows that the current negative IIP for the US is approx. 2.5 times exports but only about 30% of national income. The net foreign assets - income ratio looks quite flat by comparison, but the stationarity tests below will judge that; it will be the preferred choice for a stock-flow ratio in the subsequent sections.

Period	Series	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
1960$Q$1 to 1982$Q$4	Level	accept	reject**
	Difference	accept	accept
	2nd Difference	reject***	accept
1983$Q$1 to 2007$Q$4	Level	accept	reject*
	Difference	reject*	accept
	2nd Difference	reject***	accept
2008$Q$1 to 2016$Q$4	Level	accept	accept
	Difference	reject*	reject*
	2nd Difference	accept	reject*

Table 4.2.6: Unit root tests for foreign sector stock-flow ratio based on Foreign NFA to National Income

Source: US IMA
NLB Stock(RoW) (A:44)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

Table 4.2.1.3 presents the results of unit root tests on the net foreign assets - income ratio split across the three time periods discussed above. It shows that, even in the first period up to 1982$Q$4, both tests reject stationarity of the ratio.

Summary: Foreign Sector Stock-Flow Ratio

The plot of the US IIP in figure 4.2.11 almost gives the lie to Godley's assumption that "stock variables will not change indefinitely as ratios to related flow variables" (Godley & Cripps 1983, p.42). Even in the period up to 1982$Q$4 when the US current account was performing relatively 'normally', foreign reserves were not a constraint on income, exports or imports. One could expect to see a different outcome in the case of smaller 'balance of payment constrained' economies. The background assumption behind the concept of stock-flow norms is that the two move together, as for private net financial assets and disposable income in the original New Cambridge hypothesis; but that doesn't seem to be the case for the US IIP which seems to be able to grow without limit as long as foreigners are willing to hold US assets.

4.2.2 Capital Ratios

This section considers stocks and flows that arise when the three sector model is disaggregated. In the three sector model, sectoral transactional balances in any period are 'settled' by flows of financial assets and obligations between the sectors, non-financial capital is 'internal' to the sectors. It is for this reason that the analysis in the previous section of stock-flow norms for the three sector model concentrated exclusively on financial stocks. But once the three sector model is disaggregated, stocks of non-financial assets become 'visible'. For example, the private sector could be disaggregated into sectors for households, firms and the financial sector. Then the private expenditure of the three sector model breaks down into separate values for consumption and investment, and since net investment is the change of non-financial assets, these capital items are required to complete the model.

There are two important ratios relating to non-financial capital, namely the capital-output ratio and the inventory-sales ratio; each will be investigated for 'norm-like' behaviour in the following sections.

4.2.2.1 The Inventory-Sales Norm

(Godley & Cripps 1983, p.95) introduce an inventory-sales norm as the ratio of stocks of finished goods and work in progress to the level of final demand.

The idea is similar to that of the wealth-income norm in that firms target a particular level of inventory holding in relation to sales. Firms' decisions on how much to produce must be taken in advance of sales and, in a world of uncertainty, the level of sales is not precisely predictable. Inventories therefore fulfil the role of a buffer; if sales exceed expectations, inventory levels will fall, and conversely if sales are below expectations. The following period's production decisions are then modified in the light of current inventory levels.

In a study of inventory models, Blinder & Maccini (1991) call this the 'standard production-smoothing/buffer-stock model' of inventories. But they point out (pg.78) that inventories can be held for many other purposes, "for display purposes, as unavoidable 'pipeline' inventories, to improve production scheduling, to smooth production in the face of fluctuating sales, to minimize stockout costs, to speculate on or hedge against price movements, to reduce purchasing costs by buying in quantity, to shorten delivery lags, and so on".

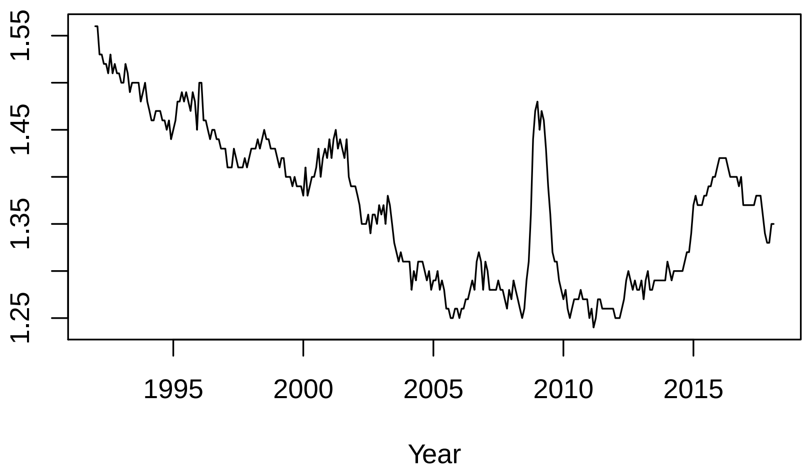

Figure 4.2.13: US Inventory-Sales Ratio: Total Business

Source: Federal Reserve Economic Data (FRED)
Inventory Sales Ratio (Table 3.2.7, line 2)

These are microeconomic views of inventories and in microeconomics, inventories are seen as a *stabilizing* factor. However, Blinder & Maccini (1991) identify that "even though investment in inventory accounts for a very small fraction of output (about 1 percent in the U.S.), changes in inventory investment account for a disproportionately large fraction of changes in output over the cycle (about 60 percent on average for seven postwar recessions in the U.S.)". They observe that production is more volatile than sales in most industries and that sales and inventory investment normally are *not* negatively correlated, both of which challenge the production-smoothing/buffer-stock model. They conclude that, at the macroeconomic level inventories can be seen as a *destabilizing* factor. The inventory-sales norm thus plays a very significant role, not just in determining the level of inventories but in pricing and profit determination (Godley & Lavoie 2007c, ch.8). In the National Income accounts GDP or gross value added is defined as the total value of final sales (S) plus the increase in inventories (ΔInv) (OECD 2008, p.107),

$$Y = S + \Delta Inv$$

Using the idea of a target level of inventories to sales, the change in inventories would be given by,

$$\Delta Inv = Inv^T - Inv{-}1 = (\sigma^T S^e - Inv{-}1) \tag{4.4}$$

where Inv^T is the target level of inventories, S^e is expected sales and σ^T is the target inventory-sales ratio, or inventory-sales norm. It is the ideal end-of-period inventories to expected sales ratio and is used as a convention for production planning and costing. Since post-Keynesian pricing theory assumes mark-up pricing (Lavoie (2014): p.156), the inventory-sales norm influences the way firms set prices.

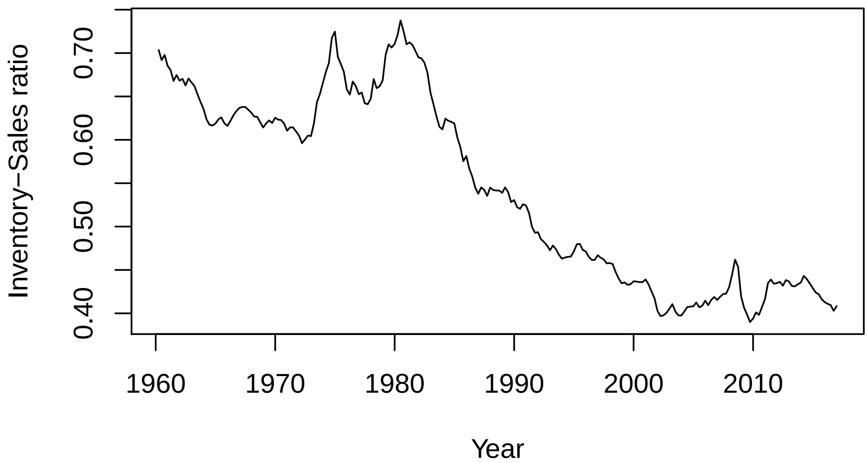

Figure 4.2.14: The Inventory Sales Ratio
Data:
1. *Source: US IMA*
Inventories (A:34)
('A:' refers to the line number in table 3.2.8)
2. *Source: Bureau of Economic Analysis*
Final Sales of Domestic Product (Table 3.2.6, line 1)

As with measures of wealth, there are various ways of measuring inventories; they are mainly broken down to manufacturing inventory, wholesale trade inventory and retail trade inventory. Manufacturing inventory can be further decomposed into finished goods, work in progress and materials and supplies. Wholesale and retail inventory is almost exclusively finished goods. Inventories are valued at cost and the effect of cost changes is compensated by the Inventory Valuation Adjustment (IVA). The US Bureau of Economic Analysis (BEA) make inventory-sales data available (BEA 2018, tables 5.8.5, 5.8.6) as does the Federal Reserve Economic Database (FRED) (FRED 2018, table ISRATIO). These provide inventory sales based on monthly sales data broken down by various industry classes giving values in the range 1.2 - 1.6. Figure 4.2.13 shows the 'Total Business' IS ratio for the period Jan 1992 to Feb 2018.

Unfortunately, this series is only available from 1992, so the figure used here is calculated from the balance sheet of the IMA which is total private inventories. To derive a figure for sales, final sales of domestic product is taken from the US National Income and Product Accounts (NIPA) with sales of services removed, since they do not contribute to inventory. Figure 4.2.14 gives a plot of this ratio. It is similar to that in figure 4.2.13 with the ratio declining steadily until the mid-2000s then with a pronounced up-spike at the time of the GFC.

Period	Series	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
$1960Q1 : 1986Q4$	Level	accept	accept
	Difference	accept	reject**
	Dbl Difference	reject***	accept
$1986Q4 : 2005Q2$	Level	accept	accept
	Difference	reject*	accept
	Dbl Difference	reject***	accept
$2005Q2 : 2016Q4$	Level	accept	accept
	Difference	reject**	accept
	Dbl Difference	reject***	accept

Table 4.2.7: Unit root tests for stock-flow ratio
based on Total Inventory to Final Sales

Data:
1. *Source: US IMA*
   Inventories (A:34)
   ('A:' refers to the line number in table 3.2.8)
2. *Source: Bureau of Economic Analysis*
   Final Sales of Domestic Product (Table 3.2.6, line 1)

Significance Levels: '***' 1%, '**' 5%, '*' 10%

Table 4.2.2.1 gives the results of unit root tests on the time series for the ratio of inventory to final sales. In the first period, $1960Q1 : 1986Q4$, the ADF finds a unit root while the KPSS test accepts stationarity; for the differences, they both find that the series are I(2). In the second period, $1986Q4 : 2005Q2$, the result is the same for the levels series, but both find that the series are I(1), and likewise in the third period, $2005Q2 : 2016Q4$. So, for all three intervals, the two tests conflict — the ADF test fails to reject the null hypothesis of a unit root and the KPSS test fails to reject the null hypothesis of stationarity.

This could be an example of the situation described in section 3.1.2.3, that the ADF test " lacks power to detect stationarity" (Gujarati & Porter 2009, p.759), especially given that the KPSS *does* detect stationarity.

The second period is one of a uniform decline in the series from 0.7 to 0.4 over a twenty year period. This could be a case of a process that is stationary around a declining trend. Figure 4.2.15 shows, in the top panel, the inventory-sales ratio in this period with a fitted line to mark the time trend; the lower panel shows the same ratio with the trend removed. Table 4.2.2.1 reports unit root tests on the levels series and the detrended series for all three periods which shows that the KPSS test accepts the null of stationarity in all three periods, for the levels series and for the de-trended series. The ADF test, on the other hand only rejects the unit root for the detrended series in the second period, and this is the only series that both tests agree on.

It is unsurprising that detrending doesn't change the outcome in the first or the third periods, since there was no obvious time trend there. However the result in the second period is interesting, since the series in that period gives the appearance of stationarity about a declining time trend, so one could tentatively infer that the inventory-sales ratio is exhibiting the behaviour expected of a 'norm' in this period.

In conclusion, the evidence for stationarity of the inventory-sales ratio in this period is not compelling, even after breaking it out into sub-periods. The ADF and KPSS tests disagree on the levels series in all three periods. However, both tests agree on stationarity of the detrended series in the second period, so it's possible that the inventory-sales ratio is playing the role of a stock-flow norm in this period.

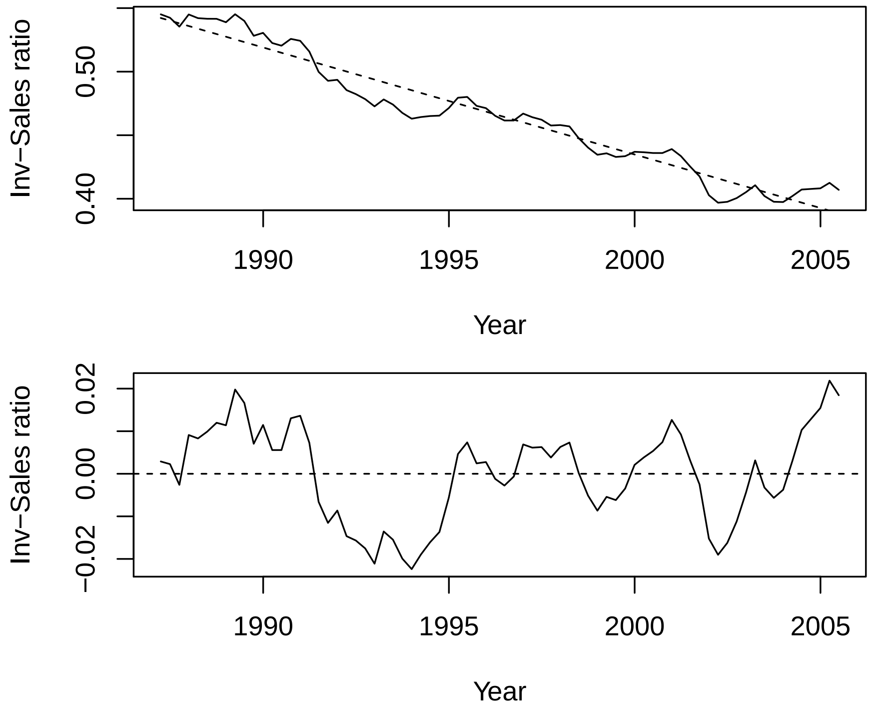

Figure 4.2.15: The Inventory Sales Ratio: 1985-2005

Data:
1. *Source: US IMA*
   Inventories$(A:34)$
   ('A:' refers to the line number in table 3.2.8)
2. *Source: Bureau of Economic Analysis*
   Final Sales of Domestic Product (Table 3.2.6, line 1)

Period	Series	ADF Test	KPSS Test
	Null Hypothesis:	Unit Root	Stationarity
$1960Q1 : 1986Q4$	Inv-Sales	accept	accept
	Inv-Sales(detrended)	accept	accept
$1986Q4 : 2005Q2$	Inv-Sales	accept	accept
	Inv-Sales(detrended)	reject**	accept
$2005Q2 : 2016Q4$	Inv-Sales	accept	accept
	Inv-Sales(detrended)	accept	accept

Table 4.2.8: Unit root tests for Total Inventory to Final Sales in three sub-periods

Data:
1. *Source: US IMA*
   Inventories (A:34)
   ('A:' refers to the line number in table 3.2.8)
2. *Source: Bureau of Economic Analysis*
   Final Sales of Domestic Product (Table 3.2.6, line 1)

Significance Levels: '***' 1%, '**' 5%, '*' 10%

In light of the earlier remarks about the volatility of inventories and their contribution to fluctuations in the business cycle cited from Blinder & Maccini (1991), one could expect significant short-term departures from any stable level and this is what is observed in the periods 1960-1980 and 2000-2016; counter-intuitively, the volatility appears to be greater in the second, 'trans-crisis' period. But in the middle period there is a clear, steady reduction in the level over an extended period. At this level of aggregation, it is not possible to say what the reasons for this decline might be, except that, in a disaggregated model, it's possible that it might correlate with changes in another ratio or other macro-level variables. This is a direction for further research as indicated in section 7.3.

4.2.2.2 The Capital-Output Ratio

The other significant non-financial stock that comes into play when the private sector is disaggregated is the *capital-output ratio*. Whereas the inventory-sales ratio reflects the volatility of inventories as the buffer stock in the fluctuating business cycle, the capital-output ratio captures the relationship between total economic output and the firm sector's stock of productive assets, so should be more stable. The fixed capital stock is slow to adjust — new investment projects typically span several periods, fixed assets are normally long-lived and their retirement also takes time.

The capital-output ratio has played a big part in various aspects of the history of economic thought around capital theory from the classical economists through Marx to the neo-classicals and especially the post-Keynesians with the Cambridge Capital Controversies of which Harcourt (2015) and Cohen

& Harcourt (2003) provide good retrospectives. Consequently, it has been implicated in the marginal productivity theories of distribution (Garegnani 1970, Robinson 1954) with its origins in the neo-classical aggregate production function, so much criticised by inter-alia Henry Phelps Brown (Phelps Brown 1957), Herbert Simon (Simon & Levy 1963), Anwar Shaikh (Shaikh 1974), and Felipe and McCombie (Felipe & McCombie 2014). While remaining cognisant of all that history, it is here simply being viewed as an empirical ratio — the ratio of firms' fixed non-financial assets to total output — to investigate whether its time series is stationary, the purpose being to determine whether it constitutes a stock-flow norm in a partial adjustment process in an SFC model of the disaggregated private sector.

In Pasinetti (1974, p.49), in a discussion of the principle of acceleration in investment, he proposes the following equation for investment,

$$I_t = \beta(\nu^* Q_{t-1} - K_{t-1}), \qquad \text{where } \beta < 1$$

where I_t is current investment, Q_{t-1} and K_{t-1} are respectively last period's output and capital stock and ν^* is the desired capital-output ratio, so $\nu^* Q$ is the desired capital stock (K^*). He writes, "The idea is that, when there is a discrepancy between the desired and actual capital stock, entrepreneurs may not carry out investments to cover the full difference, but only a fraction β of it". He calls this the 'capital-stock adjustment principle'. But this is just a partial adjustment process of the type described earlier in section 2.2.2.1, applied here to the stock-flow relationship between the capital stock and the level of output. So, under that assumption, the capital-output ratio would be acting as a stock-flow norm, influencing the level of investment. Setting I_t

to ΔK yields the familiar stock-flow form of the equation for changes to the capital stock,

$$\Delta K_t = \beta(\nu Q_{t-1} - K_{t-1}) \tag{4.5}$$

As with previous ratios, measurement of the capital-output ratio poses some practical problems. While the fixed capital stock is slow to adjust, output is not and the volatility in the ratio will be largely due to fluctuations in economic activity as expressed by the *rate of utilization*, a notional ratio that can be estimated but never precisely measured. The rate of utilization is the ratio of actual output (Q) to full-capacity output (Q^*), $u = Q/Q^*$, and writing ν^* for the desired capital-output ratio to distinguish it from ν for the actual, the desired capital stock is $K^* = \nu^* \frac{Q}{u}$ and the partial adjustment process for investment in equation 4.5 becomes,

$$\Delta K_t = \beta(\nu^* \frac{Q_{t-1}}{u} - K_{t-1}) \tag{4.6}$$

which is effectively equivalent to the investment equation from (Godley & Lavoie 2007c, p.227) if ΔK is net investment.

Figure 4.2.16 is a plot of the capital-output ratio for the US between 1960 and 2016. The values for capital are taken from the balance sheet of the US IMA, being total non-financial assets less housing wealth of the private sector with and without inventories, and using GDP in place of output (Q). Exclusion of housing wealth is justified since this does not directly contribute to output.

The ratio is more volatile than the inventory-sales ratio in figure 4.2.14. De-

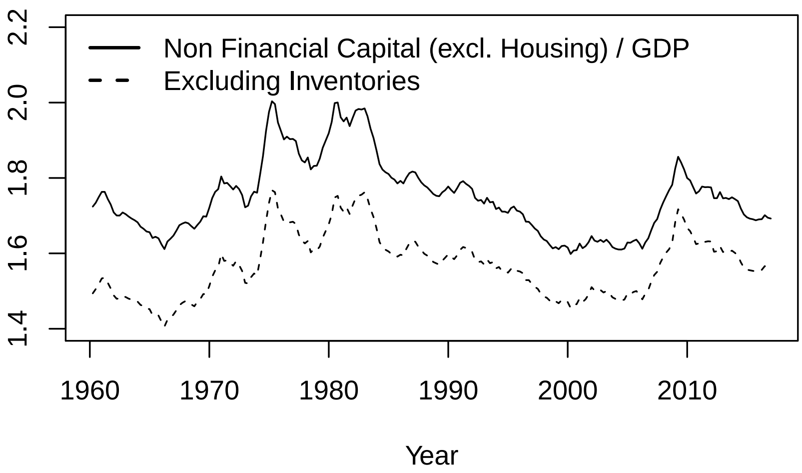

Figure 4.2.16: The Capital Output Ratio

Source: US IMA
Non-Fin Assets (A:35)
Housing Wealth (A:36)
Inventories (A:34)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)

ducting inventories from total non-financial capital doesn't change the shape of the plot significantly, showing that it is not inventory changes that are driving the volatility, although it does seem to follow a broadly similar evolution — an oscillating rising trend up to the mid-1980s followed by a declining trend until the peak of the dotcom bubble in 2000. In the inter-crisis period, it is roughly flat; following the GFC there is a sharp shift upwards, possibly due to collapsing sales, and then a gradual resumption of the previous trend in the post-crisis period.

The turning points identified above are marked on the upper scatter plot in figure 4.2.17 which is fixed capital, i.e. excluding inventories and housing wealth, plotted against GDP. Point A is at 1982$Q$4, where the ratio is at its highest level, the interval AB from 1982$Q$4 to 2000$Q$4 shows a similar steady declining trend as the inventory-sales ratio in this period; it levels off temporarily in

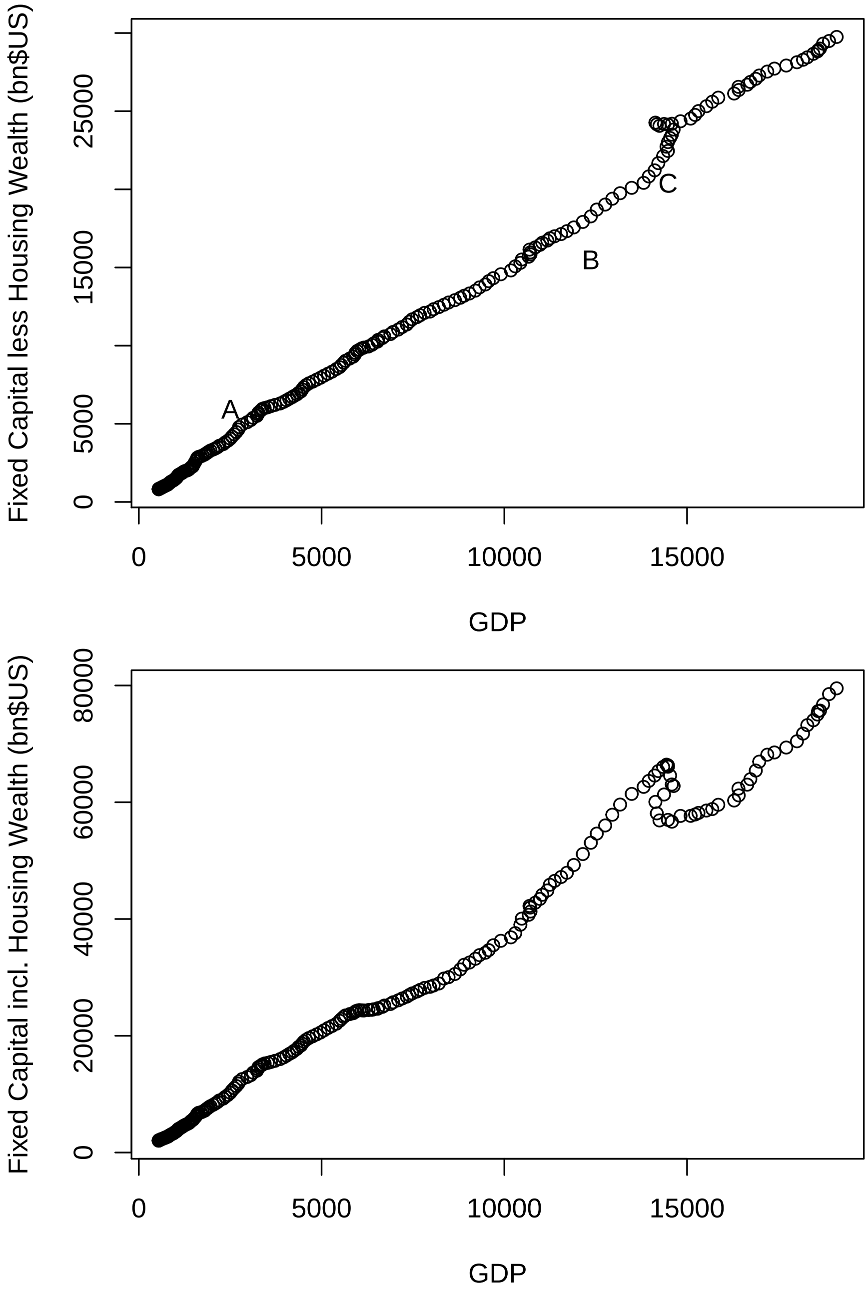

Figure 4.2.17: Scatter Plot of Capital (excl. Housing wealth) vs GDP

Source: US IMA
Non-Fin Assets (A:35)
Housing Wealth (A:36)
Inventories (A:34)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)

the period BC up to 2006$Q$1 when it starts rising in the lead up to the crisis. The recessions are marked by smooth undulations in the curve where output declines but the capital stock remains quite stable, since productive capital is normally measured at historic cost less accumulated depreciation, rather than market values. The lower panel of figure 4.2.17 includes housing wealth, and vividly shows the drop in wealth surrounding the financial crisis.

Series		1960$Q$1 to 1982$Q$4		1982$Q$4 to 2000$Q$4		2000$Q$4 to 2006$Q$1	
		ADF	KPSS	ADF	KPSS	ADF	KPSS
Capital	Level	accept	reject***	accept	reject**	accept	reject**
	Diff	accept	accept	accept	accept	accept	reject**
GDP	Level	accept	reject***	accept	reject**	accept	reject**
	Diff	accept	accept	accept	reject*	reject***	reject**
Cap-Out	Level	accept	accept	accept	accept	accept	reject**
Ratio	Diff	reject**	accept	reject***	accept	reject***	accept

Table 4.2.9: Unit root tests for the Capital Output ratio for three sub-periods
Data:
Source: US IMA
Non-Fin Assets (A:35)
Housing Wealth (A:36)
Inventories (A:34)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

The unit root tests for the ratio of fixed capital to GDP, i.e. excluding inventories and housing wealth, are reported in table 4.2.9. They present a rather confused picture; the level series for capital is non-stationary in all periods according to both tests, and the differenced series is also found to be non-stationary by one test and stationary by the other in each period, suggesting that it might be I(2). The outcome for GDP is similar. Concerning the ratio, the series in levels is found to be stationary in period 2 by the KPSS test and in period 3 by the ADF test, but non-stationary otherwise. The differenced series is found to be stationary in all periods by both tests.

4.2.2.2(a) The Capital Output ratio: Conclusions The capital-output ratio (excluding housing and inventories) has been confined in the range 1.4 to 1.75 over the course of this sample period; visually, from figure 4.2.16, it gives the appearance of being broadly stable, although volatile, showing similar 'turning points' to the inventory-sales ratio — points at which the pattern of its evolution changes.

The unit root tests were conducted on sub-series divided up according to these visually identified turning points. The 'broad stability' implied by the plot was not confirmed by the unit root tests in table 4.2.9, it was reported stationary in the second and third periods by one test, but not both. This result does not give confidence in the hypothesis of the capital-output ratio as a stable norm.

The capital-output ratio allows the formation of an equation for net investment in the form of a partial adjustment process in a similar way to the financial stock-flow ratios in section 4.2.1, however there are two caveats in relation to the use of this ratio as a stock-flow norm:

1. The stock-flow relationship is not the conventional one — the flow of output does not replenish or deplete the capital stock directly. The relevant flows which directly affect the level of the capital stock are investment and depreciation, even though changes in the level of output may change the level of depreciation.

2. Variations in the observed ratio of fixed capital to output would be mostly influenced by the rate of utilisation which will fluctuate in response to changes in aggregate demand. This would explain why the observed ratio showed similar turning points to the inventory-sales ratio which is the first to react to fluctuating levels of demand. Firms will only alter

their fixed capital stock in response to persistently high (or low) levels of capacity utilisation. They could be expected to have separate targets for the level of installed capacity, and for the level of utilisation, and these need to be treated separately. Equation 4.5 is a form of an investment function and should be applied to the target level of output rather than the actual which is affected so much by short-term fluctuations in the rate of utilisation.

4.3 Summary and Conclusions on Ratio Analysis

This chapter has studied the main macroeconomic ratios used in Godley's analyses, starting with the three *flow ratios*, each of which captures the balance condition for one of the three sectors of an open economy under the 'three balance analysis' — the fiscal stance ($Y_{GT} = G/\theta$) is the condition for balance of the public sector, the trade ratio ($Y_{XM} = X/\mu$) is the condition for balance of the external sector and the combined fiscal and trade ratio ($CFTR = (G + X)/(\theta + \mu)$) is the balance condition for the private sector. The histories of these ratios in relation to GDP was charted by means of data from the US IMA for the years 1960 to 2016. Since the fiscal stance depends on the relation between taxation and national income, the form of the relation was examined empirically. The same analysis was carried out on the propensity to import in the context of the trade ratio.

Next, the stock-flow ratios were studied, also using US IMA data, with a view to detecting 'norm-like' behaviour. The expectation of a norm is that its time series is stationary, exhibiting mean reverting behaviour, the existence of a norm could be confirmed if the individual time series are I(1) and their ratio I(0). Unit root tests were conducted on the time series and their ratios using the *Augmented Dickey-Fuller* (ADF) test, and the KPSS test (Kwiatkowski *et al.* 1992), on the grounds that the ADF test lacks power and sometimes fails to reject the null hypothesis of a unit root when none exists; the KPSS test has a null hypothesis of stationarity, and where the two agree, there is a higher degree of confidence than in each test separately. Two groups of ratios were examined, firstly the ratios of financial stocks to income that would be important for a three sector model of an open economy as will be developed in chapter 6 and secondly, ratios of non-financial stocks that will be important for more elaborate models where the private sector is disaggregated into firms and households, namely the inventory-sales ratio and the capital-output ratio.

In conclusion, of the various candidates for the private sector wealth-income norm, each exhibited periods of stationarity but the stability of the ratios was severely challenged by the economic instability of the dotcom and housing bubbles. The post-crisis period appears to be slowly reverting to stable patterns, but the time series were too short in this period for positive identification of stationarity. The most stable ratio was that based on 'NLB stock', the accumulated net lending/borrowing figure for the private sector from the US IMA balance sheet. For the ratio of government debt to income, the period around the GFC had to be excluded as government revenues collapsed in this period. The support for stationarity was inconclusive since the ADF tests failed to reject the null hypothesis of a unit root while the KPSS test accepts the null hypothesis of stationarity. Since this is a widely reported issue with ADF tests, the benefit of the doubt will go with the KPSS test.

Concerning the capital ratios, the evidence for stationarity of the inventory-sales ratio in this period is not compelling, even after breaking it out into sub-periods. This is perhaps not so surprising in light of the earlier remarks about the volatility of inventories and their contribution to fluctuations in the business cycle cited from Blinder & Maccini (1991). Despite the somewhat ambiguous results of these econometric tests, the ratio does appear to be broadly stable within the range 1.25 to 1.55. Likewise, the capital-output ratio is broadly stable between 1.4 and 1.75 but this does not translate into time series stationarity according to the unit root tests, although stationarity was reported for some of the tests. The reason was that the observed ratio mainly reflects the rate of utilisation in the short-term, and concerns about utilisation and installed capacity must be treated separately. In conclusion, this ratio is not useful as a stock-flow norm in the form of fixed capital to current output. The partial adjustment process should relate actual and target installed capacity.

Chapter 5

Ratio Analysis in Economic Dynamics

This chapter builds on the results of the preceding one by showing how the flow ratios and the stock-flow norms combine in the dynamics of the economy. The flow ratios act as 'economic stimuli', they capture the balance conditions for each of the sectors of a three sector economy; any gap between them and the level of national income represents an injection (or a leakage) from the public and foreign sectors into the private sector, impacting private sector income and expenditure and hence the private sector balance. Any non-zero sectoral balances result in flows of net financial assets between sectors. The willingness of each sector to hold assets issued by the other two is captured by the stock-flow norms. These act as stabilisers, and the levels of national income, expenditure and the stocks of financial assets of each sector mutually adjust to these norms through the action of partial adjustment processes.

The clearest exposition of this process was Godley's paper (Godley 1983) referred to earlier in section 2.2.2 for the 1983 conference to celebrate the centenary of the birth of Keynes. He opened his presentation by saying that it was his belief that Keynes viewed the workings of the economy in the following way,

> "Real demand, output and employment are determined via a multiplier process by the fiscal and monetary operations of the government and by foreign trade performance..."

The 'fiscal operations of the government and foreign trade performance' are expressed in the flow ratios; more will be said about the multiplier process below; the way that this 'real demand, output and employment determination' is moderated by the stock-flow norms is captured in the passage cited earlier on page 65 of section 2.2.2, repeated here for convenience,

> Given the fiscal stance (G/θ), so long as aggregate income exceeds its warranted level $(Y > Y^*)$ the tax yield must be such that the government's debt is falling; if income is below the warranted level $(Y < Y^*)$, the government's income is less than its expenditure so government debt is rising. Either way Y will converge towards Y^*, accompanied by changes in government debt until it reaches whatever level exactly satisfies the stock equilibrium condition (Godley 1983, p.147).

In this passage, the 'warranted' level of income (Y^*) is the level corresponding to both a 'flow' equilibrium, where $Y = G/\theta$ (the sectors are in balance, there are no inter-sectoral flows), and a 'stock' equilibrium, where $FA = \alpha \cdot (1-\theta)Y$ (the stock of financial assets has reached its target level implied by α, the stock-flow norm, stocks are not changing).

This encapsulates Godley's views about the dynamics of an economy: there are steady state levels of income expressed by the flow ratios, and the economy is naturally driven by them through the action of the multiplier towards a stock equilibrium dictated by the stock-flow norms; the transition from one state to another takes time and follows a partial adjustment process. It is this hypothesis of a steady convergence of income towards a sector balance under the action of the stock-flow norms that is the subject of this thesis and will be explored through computational simulation in this chapter and econometric analysis in the next.

However, in Godley's conference paper, the main part of the analysis concerns a closed economy, so the only flow ratio in operaton is the fiscal stance and this simultaneously becomes the condition for balance of both the public and private sectors, since with only two sectors, public sector balance means that the private sector must also be in balance. This chapter extends the model to a three sector economy in which case all three sectoral balance conditions are in action: the fiscal stance, $Y_{GT} = G/\theta$ for the public sector, the trade ratio, $Y_{XM} = X/\mu$ for the foreign sector and the combined ratio, $Y_{CFTR} = (G+X)/(\theta+\mu)$ for the private sector, where X is total exports and μ is the propensity to import. A full stock equilibrium requires that all three of these ratios hold simultaneously, i.e. that all three sectors are in balance, otherwise there will be movement of financial assets between sectors. In fact, if any two sectors are in balance, the third must also be, by the same logic as for the two sector case. So there are three possible combinations: firstly, there could be imbalances in all three sectors, secondly, one sector could be in balance with imbalances in the other two (the usual manifestation being the *twin deficit* scenario (page 35)), and finally, all sectors could be in balance. So the question becomes which balance condition will the three sector economy converge towards? The general answer, which will be explored in this chapter by means of logical simulations, is that it depends on the parameters of the flow ratios and the partial adjustment processes which are, in turn, determined by underlying structural characteristics of the economy.

The first thing is to look at the relationship between the flow ratios and the national income; the flow ratios are 'partial multipliers', reduced forms of the complete multiplier in equation 2.1 (p.51). If these are 'driving' the national income, there should be a steady state relationship between the two with the flow ratios 'leading' national income. These possibilities will be investigated in section 5.1 using the concepts of cointegration and Granger-causality. The next stage focuses on the stock-flow norms and the dynamics; section 5.2 develops the three sector multiplier incorporating the sectoral stock-flow norms. Section 5.3 incorporates the dynamics into a set of linear difference equations which prove intractable to analytical solution, but section 5.5 explores various solutions, by means of computational simulations, and demonstrates how varying the exogeneity of the sectoral expenditure items (G or X), the convergence to the flow ratios changes. This leads to a classification in section 5.6 into 'surplus' economies, i.e. those tending to run fiscal and current account surpluses, or 'deficit' or 'mixed' economies, based on their structural parameters. Finally, this classification is illustrated in section 5.7 with examples from several European economies based on Eurostat data.

5.1 The Convergence Process: the Flow Ratios as Drivers

In this section, the first stage of the dynamic process is investigated, namely the dynamic relationship between the flow ratios and the national income. To establish whether there is a relationship, several Johansen VECM models are formulated between FS and Y, and between TR and Y where FS is the fiscal stance, TR is the trade ratio and Y is the national income. These time series could be expected to be cointegrated suggesting a long-run relationship between them. But to add credence to the suggestion that the flow ratios FS and TR are 'driving' Y, Granger causality tests will be used. Granger causality was briefly introduced in section 3.1.2; it doesn't establish a cause and effect relationship in the everyday sense of the word, but determines whether adding lagged values of one time series to a model for another time series improves the explanatory power of the model. Granger causality and cointegration are connected, if two time series, x and y, are cointegrated, there must exist Granger causality either from x to y, or from y to x, or both.

Table 5.1.1 shows the results of the tests of cointegration between FS and Y and between TR and Y. In each case, the order of cointegration is 1, implying that there is a long term relationship between them. The diagnostics show that the assumption of normality of the residuals is rejected, but autocorrelation and heteroskedasticity are not a problem. The non-normality of the residuals is not considered a serious impediment in this case, since we are only interested in the order of integration and are not making inferences concerning the parameter values.

Relation	Order of Cointegration	Eqn	Jarque-Bera Test	Box-Pierce Test	Arch Test
Null Hypothesis:			Normality	No Autocorr	No Heteroskdy
FS - Y	1	FS	reject	accept	accept
		Y	reject	accept	accept
TR - Y	1	TR	reject	accept	accept
		Y	reject	accept	accept

Table 5.1.1: Diagnostics for Cointegration VECM for Flow Ratios and National Income

Source: US IMA
Fiscal Stance (C:4)
Trade Ratio (C:8)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

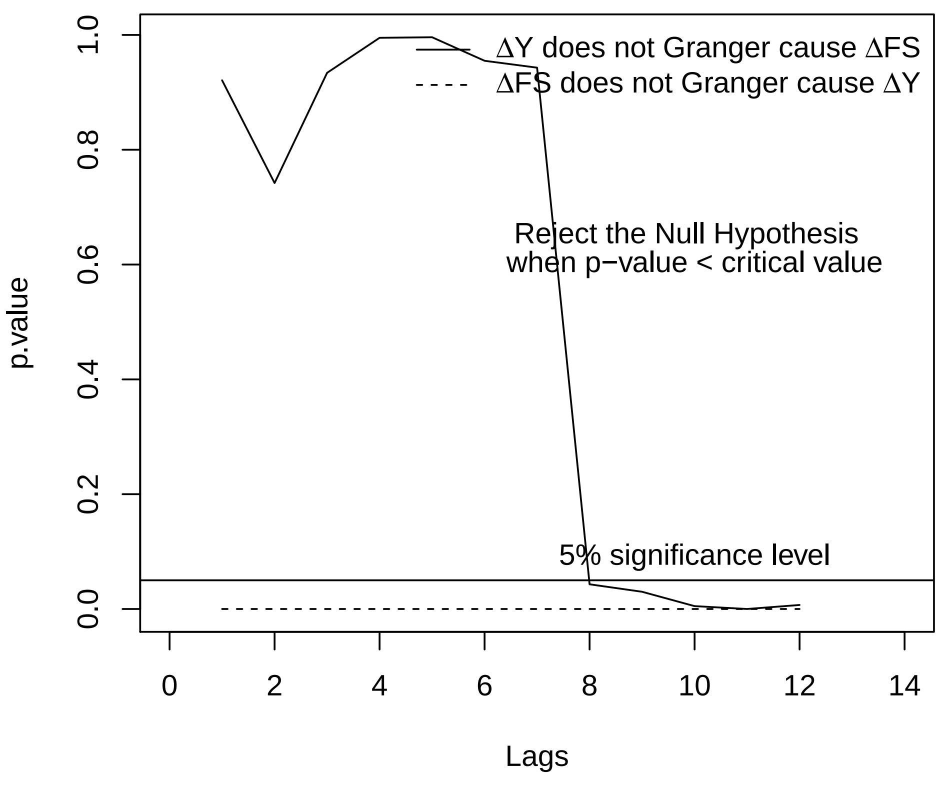

Figure 5.1.1: Granger Tests for FS and Y

Source: US IMA
Fiscal Stance (C:4)
Gross Domestic Product (A:1)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)

Since FS and Y are cointegrated, there must be Granger causality between them; the results of the Granger causality tests are shown in figure 5.1.1 for the case of the fiscal stance and national income. The plot shows two lines, the solid line being the p-values for the null hypothesis "ΔY does not Granger-cause ΔFS" and similarly the dotted line for the null hypothesis "ΔFS does not Granger-cause ΔY". If the p-value is less than the critical value (the 5% line is shown) the null hypothesis can be rejected. The solid line shows that the statement 'ΔY does not Granger-cause ΔFS' cannot be rejected for lags less than 8, but the alternative statement 'ΔFS does not Granger-cause ΔY' can be rejected at all lags. There are conditions that must hold for the validity of Granger tests, firstly, the series must be stationary which is the case here since they have been differenced to produce ΔFS and ΔY; also, there must be no auto correlation of the residuals, which is confirmed in table 5.1.1.

What this suggests is that changes in FS help to explain changes in Y for up to eight time periods after the change, but the converse is not true. After eight time periods, secondary interactions build up so that both variables become mutually inter-related and are explained equally by each other. This finding supports Godley's assertion that the fiscal stance drives national income (it certainly doesn't refute it), but of course does not establish a cause and effect relationship. It could be said that Granger causality is a necessary but not sufficient condition for true causality.

Similar results were obtained for the relationship between changes in the trade ratio and changes in income, and also between changes in income and changes in the stock of private financial assets, although plots of these are not shown. This establishes a 'Granger causal sequence', $\Delta FS, \Delta TR \rightarrow \Delta Y \rightarrow \Delta FA$, which is in line with Godley's assertions about the dynamics of the economy. If further substantiated by the investigations in later sections, it will also challenge the mainstream view (discussed in section 2.1.1, p.28) that fiscal policy has no effect on real activity.

5.2 The Convergence Process: the Multiplier and Stock-Flow Norms

The earlier discussion on page 230 of Godley's description of the convergence process involves two simultaneous conditions, the first was called a 'flow equilibrium' requiring the equality of national income with the fiscal stance[1],

$$Y = G/\theta$$

and the second was a 'stock equilibrium' expressing the condition for balance between the stock of financial assets and disposable income under the wealth-income norm,

$$Y(1-\theta) = FA/\alpha$$

For a full stock equilibrium, these two conditions must hold simultaneously. The two conditions characterise the final steady state, but they say nothing about how the transition to that state comes about. In the passage attributed

[1]The fiscal stance is G/θ; it is one of the main ̀flow ratios' that, according to Godley's hypothesis drives national income through the multiplier. The way it does this was set out in the passage on page 65. As explained on page 65, if $Y^* < G/\theta$, (an expansionary fiscal stance), the government is running a deficit and government debt will be rising (not a full-stock equilibrium) and vice versa. The purpose of re-introducing it now is to discuss how it and the second condition for full-stock equilibrium $Y^*(1-\theta) = FA/\alpha$ combine to yield a convergence towards the stock-flow norm.

to Keynes cited above (p.230), Godley appeals to a multiplier process; income Y converges under the action of the multiplier to a new equilibrium consistent with the fiscal stance and the stock-flow norms. Section 2.2.1.2 derived a 'complete multiplier' (Leite 2015) which was an expression reformulated from the national income acccounting identity,

$$Y = \frac{c_0 + I + G + X}{1 - c_1(1 - \theta) + \mu} \tag{5.1}$$

where the multiplier is $\frac{1}{1-c_1(1-\theta)+\mu}$, the reciprocal of the denominator.

Traditionally, multipliers in macroeconomics have been used to determine new equilibrium levels of income following a change in one of the autonomous variables (i.e. income independent — those in the numerator of equation 5.1), but not to describe the *traverse* from one state to the other; it couldn't possibly do so since the expression in equation 5.1 is time independent — the autonomous variables are assumed to be constant, so the transition will occur in a single period. In fact, many writers have asserted that the time period *is* the multiplier period, "the time period is the duration required for the multiplier to act" (de Carvalho 1996, p.324) and Leijonhufvud (1968, pp.60-66) introduces the idea that the period involved in equilibrium definitions in *The General Theory* (Keynes 1936) is the multiplier period. Kalecki (1937, pp.78-80) implies that the multiplier period is the unit for the short period and describes "the dynamic process as a chain of short period equilibria".

In the simulations later in section 5.5, there is a step change (shock) to one of the exogenous variables and a period of transition to a new state. A comparative static analysis would compare states of the system at the beginning and end of the simulation when 'equilibrium' has been restored. A dynamic analysis considers the path of the transition during the disequilibrium but that requires that the multiplier be expressed in terms of time. This will be brought about by a consideration of wealth and income in the consumption function.

In Godley & Lavoie (2007c, p.140), the Haig-Simons definition of income (due to Haig (1921) and Simons (1938)) is defined as "consumption plus the change in wealth" in compliance with Hicks' definition of income as "the maximum amount of money which an individual can spend this week, and still expect to be able to spend the same amount in real terms in each ensuing week" (Hicks 1939, p.174). These definitions recognise the impact of wealth effects on consumption and saving which can be captured by introducing a lagged wealth term into the consumption function. This gives rise to a new form of the consumption function,

$$C_t = c_1 YD_t + c_2 W_{t-1} \qquad 0 < c_2 < c_1 < 1 \tag{5.2}$$

Note that the income term is still nominal disposable income as defined in the national income identity, not the Haig-Simons income since there is a problem in defining consumption in terms of 'consumption plus the change in wealth'. But the effect of changes in wealth are now captured since capital gains from previous periods feed into the start-of-period wealth term (W_{t-1}). Empirical studies show that only lagged measures of capital gains have a significant impact on current consumption (Baker 1998, p.65). So the lagged wealth term replaces the constant term (c_0) in the consumption function appearing in the numerator of equation 5.1 above and the multiplier expression becomes,

$$Y_t = \frac{c_2 W_{t-1} + I + G + X}{1 - c_1(1-\theta) + \mu} \tag{5.3}$$

The multiplier itself hasn't changed, it is the *multiplicand* that is different since it now explicitly incorporates the time dimension. It embodies the stock-flow dynamic whereby opening period stocks influence current period flows, which in turn update following period stocks, etc. By contrast, in the previous multiplier expression (equation 5.1) time is implicit, it defines the new equilibrium state corresponding to the new values of the exogenous variables but not the path taken to get there.

So, the route by which income converges towards the fiscal stance in Godley's example now has two components; firstly, the direct income effect of the higher government expenditure and secondly, the stock-flow effect, since if $Y < G/\theta$, government debt is increasing (and therefore also private financial assets (W_t) in a closed economy). As wealth increases, income is further increased through the multiplier up to the point where wealth stabilises at the target level dictated by the wealth-income norm $FA^* = \alpha Y^*(1-\theta)$. The converse applies if $Y > Y^*$. This exact same traverse is simulated in Godley & Lavoie (2007c, pp.68-78) showing the convergence of income and wealth to steady state levels following a step change in the fiscal stance.

The foregoing discussion proceeded in the context of a closed economy with private sector expenditure disaggregated into a consumption function and exogenous investment, since it was based on the example used by Godley in his Keynes conference paper (Godley 1983). However, for the purposes of this study, the subject is a three sector economy with an aggregated private sector. There are three stock-flow ratios, one for each sector, and in place of a consumption function and exogenous investment there is a private expenditure function.

The private expenditure function is derived from the assumption that private sector expenditure and saving are determined as a balance between disposable income and the acquisition of financial assets as expressed in the wealth-income norm which captures the target level of financial assets appropriate to the current level of disposable income,

$$FA^* = \alpha \cdot YD$$

The change in private financial assets in a period is proportional to the gap between this target level, and the actual level at the beginning of the period,

$$\Delta FA = \phi(FA^* - FA_{-1})$$

This is a *partial adjustment process* (defined in section 2.2.2.1) where $\phi < 1$, the constant of proportionality, is referred to as the *speed of adjustment* factor. It captures the assumption that the gap is not completely closed in a single period, but only partially; i.e. some proportion of the disequilibrium between target and actual is reduced in each period. Combining these two equations with the following 'adding-up constraint' from the flow of funds, $\Delta FA = YD - PX$ leads to the following expression for PX,

$$PX = (1 - \phi\alpha)YD + \phi FA_{-1} \tag{5.4}$$

This equation is comparable, but not the same as, the New Cambridge private expenditure function discussed in section 2.1.2. Section 5.2.1 below provides a reconciliation between equation 5.4 and various forms of the New Cambridge equation.

By assuming the presence of similar norms in the public and foreign sectors, comparable partial adjustment processes can be derived for them as well. For the public sector, let γ represent the ratio of public sector debt to national income (the debt-GDP ratio). Then $GD^* = \gamma \cdot Y$ becomes a target or norm for public sector debt. In the EU's stability and growth pact, this is set at 60%, Reinhart & Rogoff (2009) suggest that a ratio of public debt to GDP above 90% leads to reduced economic growth, a claim that has given rise to a literature all of its own. If the debt-GDP ratio fulfils the function of a norm, there must be a dynamic linking changes in debt and changes in GDP such as the following partial adjustment process,

$$\Delta GD = \psi(GD^* - GD_{-1}) \qquad 0 < \psi < 1$$

which, after substitution of $\Delta GD = G - T$ where $T = \theta Y$ and $GD^* = \gamma Y$ yields an expression for public sector expenditure,

$$G = (\theta + \psi\gamma)Y - \psi GD_{-1} \tag{5.5}$$

Following the same logic for the foreign sector, where the accumulated financial assets of the domestic economy in relation to the rest of the world are its foreign reserves (FR) and $\eta = FR^*/Y$ is a stock-flow norm defining a target level of foreign reserves in relation to national income, then a partial adjustment process for the foreign sector linking changes in foreign reserves to the target is,

$$\Delta FR = \xi(FR^* - FR_{-1}) \qquad 0 < \xi < 1$$

and applying the same substitutions as above, $\Delta FR = X - M$ where $M = \mu Y$ and $FR^* = \eta Y$ yields an expression for foreign sector expenditure,

$$X = (\mu + \xi\eta)Y - \xi FR_{-1} \tag{5.6}$$

Equations 5.5 and 5.6 are not meant to imply that G and X are functions of Y, but rather to propose the existence of an adjustment process between the flows G, X, Y and the stocks under the action of the stock-flow norms γ and η, similar to that of the private sector wealth-income norm α.

Combining these three expenditure expressions into the national income identity gives rise to a new statement of the complete multiplier,

$$Y \equiv PX + G + X - M$$

$$Y + M = (1 - \phi\alpha)YD + \phi FA_{-1} + (\theta + \psi\gamma)Y - \psi GD_{-1} + (\mu + \xi\eta)Y - \xi FR_{-1}$$

which gives, after substitution of $M = \mu Y$ and $YD = (1 - \theta)Y$, a new form of the multiplier expression in terms of stocks and stock-flow norms,

$$Y_t = \frac{\phi FA_{t-1} - \psi GD_{t-1} - \xi FR_{t-1}}{1 + \mu - (1 - \theta)(1 - \phi\alpha) - (\theta + \psi\gamma) - (\mu + \xi\eta)} \tag{5.7}$$

This provides a three sector equivalent of the convergence process for the closed economy that Godley described in his Keynes' centennial conference paper cited on page 230. There, the fiscal stance (G/θ) was given and national income (Y) converged to the fiscal stance under the action of the multiplier and the wealth-income norm. In this three sector equivalent, there are three flow ratios, the fiscal stance (G/θ), the trade ratio (X/μ) and the balance condition for the private sector ($(G+X)/(\theta+\mu)$). The settings of these ratios expresses the level of stimulus to the economy and the response is determined from the multiplier expression in equation 5.7. The question raised earlier of which balance condition national income would converge towards can now be addressed in this new framework.

5.2.1 Alternative Forms of the New Cambridge Equation

The partial adjustment expression for PX in equation 5.4 can be compared to the New Cambridge equation, first discussed in section 2.1.2. It's important to state that there was not just a single 'New Cambridge equation', but that it evolved with use. The equation arose from the 'New Cambridge Hypothesis' (quoted on page 38) and its first empirical estimation was presented to the Select Committee on Public Expenditure in 1974 and discussed in Cripps & Godley (1976). The form of the original equation was,

$$PX = a_1YD + a_2YD_{-1} + a_3HP + a_4BA + a_5S \tag{5.8}$$

meaning that current private expenditure is determined by current and the previous period's disposable income, and the flow of net lending to the private sector (which is represented by HP, the change in hire purchase agreements,

BA, the change in bank advances and S, the change in stocks (both the value of the physical increase in stocks and also stock appreciation). The estimates of the coefficients are given in Cripps & Godley (1976) but are not of concern here except to say that $a_1 + a_2 \approx 1$, which says that all of private disposable income is spent within one year. One of the ways that the equation evolves in this period is its reformulation in money rather than in real terms; this didn't change the form of the equation, but the estimates of the parameter values changed and the new formulation was much better at capturing the effects on expenditure of the large changes in nominal values in this period.

But what is of interest is the *form* of the equation,

$$PX = f(YD, YD_{-1}, NL, S) \tag{5.9}$$

where NL is the flow of net lending to the private sector. The form of the equation shows that it applies to a disaggregated private sector since net lending comes from the financial sector which is within the private sector and the change in stocks refers to changes in inventory, which are internal to the private sector. For comparison, the form of equation 5.4 is

$$PX = f(YD, FA_{-1}) \tag{5.10}$$

This applies to the aggregate private sector since FA refers to inter-sectoral financial assets. The most notable later version of the New Cambridge equation was that used in Godley (1999c); it took the form

$$PX = f(YD, NL, FA_{-1}) \tag{5.11}$$

It also works on the disaggregated private sector. The key point is that it includes net lending as one of the explanatory variables for private expenditure which an aggregated equation of the form of 5.10 cannot do because net lending is not 'visible' at the aggregated level, it is internal to the private sector.

The reason that all this matters is that equations of the form of 5.10 and hence the partial adjustment process in equation 5.4 above are likely to be mis-specified — one of the key determinants of PX is NL which is not available at this level of aggregation, and so is a missing variable in equations of this form. This consequence of the level of aggregation was discussed in Cripps & Godley (1976) where it was stated that the form of the equation would vary depending on the level of aggregation at which it was applied, "the main interpretation [...] entirely depends on the level of aggregation and coverage of financial claims to which it is intended to apply [...] taking the private sector as a whole, net 'financial' assets constitute net holdings by the private sector of overseas assets and public sector debt. At the other extreme, from the point of view of an individual household or firm, net financial assets could mean all paper assets and liabilities including those to other private individuals and organisations, such as mortgages, bank deposits, pension rights, company securities, etc." (p.49). But the important point is that the relationship between stocks of financial assets and income is asserted to apply at *all* levels of aggregation; so equations of the form of 5.10 and 5.11 should be equally valid at the appropriate level. Table 5.2.1 illustrates the relationship between levels.

	Private Sector				Public Sector	
	Households and Firms		Financial Sector			
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
1	D	L	L	D		
2	GD_h		GD_f			GD
3	$NFA_h = GD_h$		$NFA_f = GD_f$			
4	$NFA_P = GD_h + GD_f$				$NFA_G = -GD$	
5	$\boldsymbol{NL = \Delta L = \Delta D}$					
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
6	$D + \Delta D$	$L + \Delta L$	$L + \Delta L$	$D + \Delta D$		
7	GD_h		GD_f			GD
8	$NFA_h = GD_h$		$NFA_f = GD_f$			
9	$\boldsymbol{PX = a_1 YD + a_2 NFA_h + a_3 NL}$					
10	$NFA_P = GD_h + GD_f$				$NFA_G = -GD$	
11	$\boldsymbol{PX = b_1 YD + b_2 NFA_P}$					

Table 5.2.1: Balance Sheets for Disaggregated Private Sector

Symbols:

$D, \Delta D$	Bank Deposits
$L, \Delta L$	Bank Loans
NL	Net Lending to private sector
GD, GD_h, GD_f	Government Debt, held by households and the financial sector
NFA, NFA_h, NFA_f	Net Financial Assets, held by households, the financial sector
NFA_P, NFA_G	Aggregated NFA for private sector, Government sector

The private sector of the three sector model has been disaggregated into a Households and Firms (HHF) sector and a Financial Sector (FS). The Public sector is unchanged and the Foreign sector is not shown. Lines 1-4 show the balance sheets of the sectors; line 1 shows the state of lending to the HHF sector. Loans are liabilities of the HHF sector and assets of the financial sector; loans generate deposits which are assets of the HHF sector and liabilities of the financial sector. Line 2 shows that the government has issued debt GD which is held by the private sector split between GD_h for the HHF sector and GD_f held by the financial sector. Line 3 shows that the private lending nets out on aggregation, since loans must equal deposits for the balance sheet to balance; so the net financial assets of the HHF sector are just its holdings of government debt, and likewise for the financial sector. Line 4 shows that the net financial assets of the consolidated private sector is just the total government debt. Line 5 shows that if net lending takes place, loans and deposits will change by the same amount. Lines 6-8 just repeat the balance sheet showing the effect of the net lending, but at line 8, the net financial assets position is not (yet) changed by the net lending. Its effect is shown at line 9 where it impacts private expenditure. The initial effect of NL is on PX, but in subsequent periods will impact income and feed through into the private sector balance between income and expenditure which will in turn lead to changes in the balance sheet. This is possibly the reason that the New Cambridge equation had terms for lagged income (YD_{-1}).

Comparing the equations for PX at lines 9 and 11, that at line 9 is of the form of 5.11 on the disaggregated private sector whereas that at line 11 is of the form of 5.10 on the consolidated private sector. The difference being the absence of the NL term in the consolidated equation, and the difference in the net financial assets term, NFA_h vs NFA_P. For the two forms of the equation to give consistent results, $a_2NFA_h + a_3NL \approx b_2NFA_P$. It's likely that NFA_h will be small or even zero, since most government debt will be held by the financial sector, households and non-financial firms normally hold very little. The equivalence of the two forms of the equation will be disturbed by changes to NL but restored as the changed lending feeds through into incomes and changed levels of government debt; "this implies that government debt has to adjust to changes in income and to changes in private debt" (Godley 1983, p.147). And the mechanism by which this occurs is described in the quote on page 65.

In conclusion, the two forms of the equation for PX operate at different levels of aggregation on different variables. The disaggregated version could be expected to be more responsive to changes in net lending, but the aggregated version should respond with a lag as the changed lending works its way through expenditure into modified asset values. This comparison will be revisited in chapter 6 when estimates of the aggregated form have been produced.

5.3 The Convergence Process: Linear Difference Equations

The schematic in figure 5.3.1 below shows the basic inter-relationships of the flows in the three sector model. The main expenditure flows, PX, G and X, together with the initial values of the three stock variables, FA_{-1}, GD_{-1} and FR_{-1} (private sector financial assets, government debt and foreign reserves respectively) and the parameters μ and θ completely determine the model.

Starting from the three expenditures, PX, G and X, in the box in the centre, knowing the parameter μ, the average propensity to import, allows national income Y and imports M to be calculated, and hence the flow $X - M$ which is the foreign sector balance (equivalent to the change in net foreign assets ΔFR). Combining this with the starting stock (FR_{-1}) produces the new value of the stock FR, completing the circuit on the right hand side of the diagram.

Resuming in the centre, knowing income Y and the tax rate θ, it is possible to compute tax T and hence disposable income YD. From this follow the balances for the public sector $T - G$ and the private sector $YD - PX$, and the flow of funds items ΔFA, net financial assets for the private sector and ΔGD, the change in the government debt. Given the initial values of the stocks and the computed values of the changes in stocks, the new stock values can be derived.

The schematic shows dotted lines from these new stock values back to the expenditure items, which completes the cycle. The expenditure flows determine the new stock values and the updated stocks in turn influence the expenditure levels in the next period. The dotted lines indicate the next iteration of the cycle in which partial adjustment processes determine the new values of the flows. The multiplier process developed in the previous section incorporated the sectoral partial adjustment processes to calculate income directly, starting from these updated stock values. In this section, linear difference equations will be developed to calculate the new flow values and the next period's stock values.

Starting from the basic statement of the partial adjustment process for each

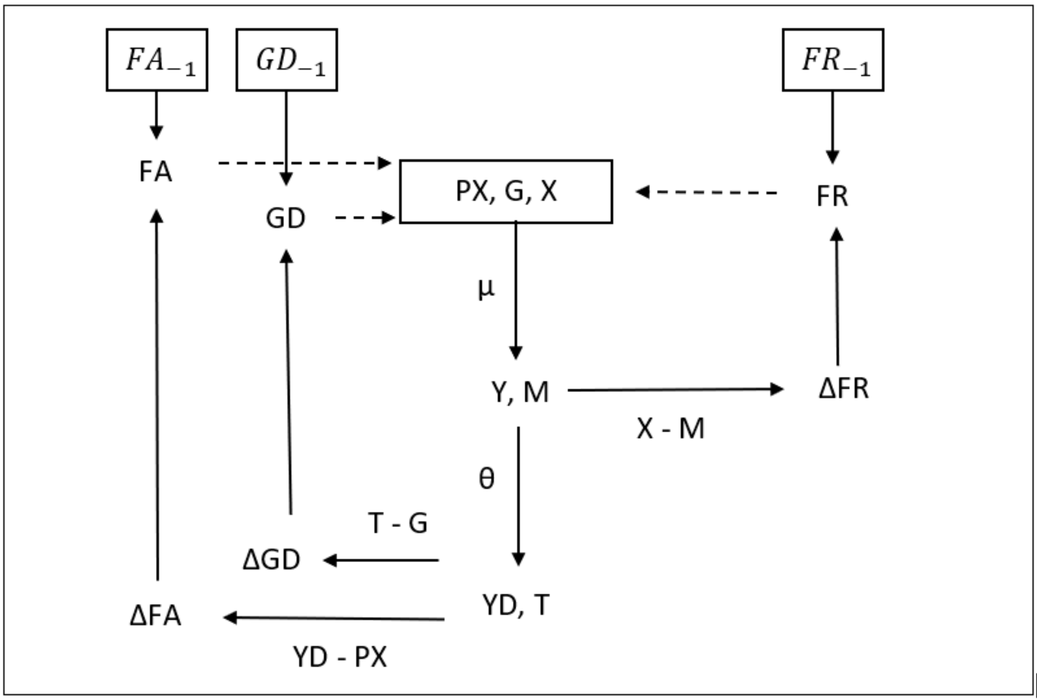

Figure 5.3.1: A Schematic of the Logical Dependencies in the three sector model

sector in terms of a 'target' value for its financial assets,

$$\Delta FA_p = \phi(FA^*{}_p - FA_{p_{-1}}) \qquad \Delta FA_g = \psi(FA^*{}_g - FA_{g_{-1}}) \qquad \Delta FA_f = \xi(FA^*{}_f - FA_{f_{-1}})$$

then eliminating the target levels by introducing the stock-flow norms which relate the target levels to the relevant flow,

$$\alpha = \frac{FA^*{}_p}{YD} \qquad \gamma = \frac{FA^*{}_g}{Y} \qquad \eta = \frac{FA^*{}_f}{Y}$$

and by using the accounting result that,

$$\Delta FA_p = YD - PX \qquad \Delta FA_g = \theta Y - G \qquad \Delta FA_f = \mu Y - X$$

yields

$$YD - PX = \phi(\alpha YD - FA_{p_{-1}}) \qquad \theta Y - G = \psi(\gamma Y - FA_{g_{-1}}) \qquad \mu Y - X = \xi(\eta Y - FA_{f_{-1}})$$

From the national income identity, $Y \equiv C + I + G + X - M$ with $C + I$ replaced by PX and μY substituted for M, the following expressions for Y and YD follow,

$$Y = \frac{PX + G + X}{1 + \mu} \qquad \text{and} \qquad YD = \frac{(1 - \theta)}{(1 + \mu)}[PX + G + X]$$

Substituting for Y and YD in the expressions for each of the sectoral expenditure items (and changing to the more familiar notation FA, GD and FR in place of $FA_{p_{-1}}$, $FA_{g_{-1}}$ and $FA_{f_{-1}}$ respectively), results in the following expressions for the expenditure flows,

$$PX = \frac{(1 - \theta)(1 - \phi\alpha)}{(1 + \mu)}[PX + G + X] + \phi FA_{-1}$$

$$G = \frac{(\theta + \psi\gamma)}{(1 + \mu)}[PX + G + X] - \psi GD_{-1}$$

$$X = \frac{(\mu + \xi\eta)}{(1 + \mu)}[PX + G + X] - \xi FR_{-1}$$

These can be more compactly cast in matrix format,

$$\begin{bmatrix} PX \\ G \\ X \end{bmatrix} = \boldsymbol{A} \begin{bmatrix} PX \\ G \\ X \end{bmatrix} + \begin{bmatrix} \phi & 0 & 0 \\ 0 & -\psi & 0 \\ 0 & 0 & -\xi \end{bmatrix} \begin{bmatrix} FA \\ GD \\ FR \end{bmatrix}_{-1}$$

where $\boldsymbol{A}$ is the coefficient matrix formed from the parameters,

$$\boldsymbol{A} = \begin{bmatrix} \frac{(1-\theta)(1-\phi\alpha)}{(1+\mu)} & \frac{(1-\theta)(1-\phi\alpha)}{(1+\mu)} & \frac{(1-\theta)(1-\phi\alpha)}{(1+\mu)} \\ \frac{(\theta+\psi\gamma)}{(1+\mu)} & \frac{(\theta+\psi\gamma)}{(1+\mu)} & \frac{(\theta+\psi\gamma)}{(1+\mu)} \\ \frac{(\mu+\xi\eta)}{(1+\mu)} & \frac{(\mu+\xi\eta)}{(1+\mu)} & \frac{(\mu+\xi\eta)}{(1+\mu)} \end{bmatrix}$$

Since the expenditure vector appears on both sides of the above equation, it can be reduced to,

$$\begin{bmatrix} PX \\ G \\ X \end{bmatrix} = (\boldsymbol{I} - \boldsymbol{A})^{-1} \begin{bmatrix} \phi & 0 & 0 \\ 0 & -\psi & 0 \\ 0 & 0 & -\xi \end{bmatrix} \begin{bmatrix} FA \\ GD \\ FR \end{bmatrix}_{-1} \tag{5.12}$$

which expresses the main expenditure items in terms of the starting values of the stocks, completing the cycle depicted in figure 5.3.1. Equation 5.12 effectively instantiates the process represented by the dotted lines in the figure.

The final values of the stocks are determined by taking the process one step further. They are derived from their starting values and the flows in each period,

$$FA - FA_{-1} = YD - PX \qquad GD - GD_{-1} = G - \theta Y \qquad FR - FR_{-1} = X - \mu Y$$

which, by substituting from equation 5.12 allows the final values of the stocks to be expressed in terms of their starting values in a first order linear difference equation,

$$\begin{bmatrix} FA \\ GD \\ FR \end{bmatrix} = \begin{bmatrix} \frac{-(\theta+\mu)}{1+\mu} & \frac{1-\theta}{1+\mu} & \frac{1-\theta}{1+\mu} \\ \frac{-\theta}{1+\mu} & \frac{1+\mu-\theta}{1+\mu} & \frac{-\theta}{1+\mu} \\ \frac{-\mu}{1+\mu} & \frac{-\mu}{1+\mu} & \frac{1}{1+\mu} \end{bmatrix} \boldsymbol{(I-A)}^{-1} \begin{bmatrix} \phi & 0 & 0 \\ 0 & \psi & 0 \\ 0 & 0 & \xi \end{bmatrix} \begin{bmatrix} FA \\ GD \\ FR \end{bmatrix}_{-1} \tag{5.13}$$

The existence of solutions to this equation will depend on whether $\boldsymbol{(I-A)}$ has an inverse, which requires that its determinant $|\boldsymbol{(I-A)}|$ is non-zero, which means that

$$\psi\gamma + \xi\eta \neq \phi\alpha(1-\theta)$$

If that condition is satisfied and $\boldsymbol{(I-A)}^{-1}$ exists then the difference equation can be written

$$\begin{bmatrix} FA \\ GD \\ FR \end{bmatrix} = \boldsymbol{B} \begin{bmatrix} FA \\ GD \\ FR \end{bmatrix}_{-1} \tag{5.14}$$

where $\boldsymbol{B}$ is the product of the three coefficient matrices.

The general form of a linear difference equation in matrix format, by consulting standard texts on linear algebra, e.g. Gandolfo (2009) is

$$\boldsymbol{y_{t+1}} + \boldsymbol{A}\boldsymbol{y_t} = \boldsymbol{C} \tag{5.15}$$

where the $\boldsymbol{y}$ are vectors, $\boldsymbol{A}$ is a coefficient matrix and $\boldsymbol{C}$ is a matrix of constant terms. The general solution will consist of the sum of two components: a *particular integral* $\boldsymbol{y_p}$ which is any solution of the complete non-homogeneous equation 5.15, and a *complementary function* $\boldsymbol{y_c}$ which is the general solution of the homogeneous equation,

$$\boldsymbol{y_{t+1}} + \boldsymbol{A}\boldsymbol{y_t} = 0$$

The particular integral $\boldsymbol{y_p}$ defines the long-term or steady-state solution and the complementary function $\boldsymbol{y_c}$ determines the transients, the dynamic path that the system takes on the way to the steady-state. The transient behaviour of the system can be determined from the eigenvalues of the matrix $\boldsymbol{A}$. If each eigenvalue has a modulus that is less than one the solution is convergent, otherwise it is explosive. Convergence is monotonic for real and positive eigenvalues, it is cyclical where there is a complex conjugate pair and it is oscillatory for negative eigenvalues.

Comparing this general pattern with equation 5.14, it can be seen immediately that there is no constant term and therefore no particular integral $\boldsymbol{y_p}$ and therefore no steady-state solution. Equation 5.14 is homogeneous and therefore the solution consists of the complementary function $\boldsymbol{y_c}$ only. There is no steady-state, only transients. This is to be expected since any constant term in the difference equation would be formed of the exogenous variables of the system, but here there are no exogenous variables, everything is endogenous. This is potentially problematic since such a system is likely to be unstable. Any combination of fixed parameters will either lead to eigenvalues greater than one in which case the values of the stocks will increase constantly over time, or if the eigenvalues are less than one the system will spiral in to zero. Of these two alternatives, the case of eigenvalues very slightly greater than one is the only one that admits of a meaningful economic interpretation, since in fact most modern economies grow over time and consequently stock values will steadily increase.

The other consideration is that in a real economy, parameter values will not be constant, but will fluctuate in response to 'shocks' or random disturbances in its structure and its environment. It is often assumed in applied economics work that there is a stable 'data generating process' underlying the data we observe and that standard errors in parameter values are due to inaccuracies in measurement, but it is equally plausible and wholly consistent with a *complex adaptive systems* view of an economy (as proposed in section 3.1.1), that it is the parameters themselves that are varying, and that the values we observe are random draws from some underlying distibution of parameter values. In this case, the eigenvalues will also vary and it could be expected that they will fluctuate around one, a little greater than one leading to growth of the system, a little below one leading to contraction or recession.

These conjectures could be explored analytically by determining expressions for the eigenvalues of matrix $\boldsymbol{B}$ in equation 5.14 since the characteristic equation of the matrix is a cubic,

$$k^3 - tr(\boldsymbol{B})K^2 + (CF_{11} + CF_{22} + CF_{33})k - det(\boldsymbol{B}) = 0$$

where k are the eigenvalues, $tr(\boldsymbol{B})$ is the trace of $\boldsymbol{B}$, CF_{ij} is the cofactor of element ij of $\boldsymbol{B}$ and $det(\boldsymbol{B})$ is the determinant of $\boldsymbol{B}$. Substitution of the parameters from matrix $\boldsymbol{B}$ should allow the derivation of limits and constraints on the parameter values consistent with eigenvalues leading to stable solutions of equation 5.14, but in practice, given that $\boldsymbol{B}$ is already the product of three matrices, the expressions for the terms in the characteristic equation become so tortuous that no meaningful conclusions can be drawn. Instead, the analysis will proceed by means of simulation in the next section and be explored empirically in section 6.4 by means of a VAR model.

5.4 The Convergence Process with Growth

The models that have been developed so far have implicitly assumed that in the equilibrium state, income is constant. In a full stock equilibrium, stocks are not changing, $\Delta FA = 0 = FA^* - FA_{-1} = \alpha YD - FA_{-1}$, so $YD = FA_{-1}/\alpha$; and since FA is constant in a full stock equilibrium and α is also defined to be constant, income YD must be constant in equilibrium. The equilibrium that emerges is a *stationary state*, as opposed to a *steady state* where stocks are changing at a steady growth rate. The convergence process under study here assumes that the drivers of the models are the flow ratios, the fiscal stance (G/θ) and the trade ratio (X/μ), and that income will adjust through the multiplier to levels set by those flow ratios, subject to the stabilising effect of the stock-flow norms. In the models in Godley & Cripps (1983), the dynamics involves a shock change to income followed by a transition in which stocks and expenditure adjusts to a new stationary equilibrium. Most of those in Godley & Lavoie (2007c) involve a shock to one of the exogenous variables, followed by a transition in which income and expenditure adjust to arrive at a new stationary equilibrium state. Real data (e.g. figure 4.1.1, p.161 show that, rather than converging to new stationary states under the action of random shocks, the flow ratios, the flows and the stocks all increase at a roughly steady rate, compounded over time.

In a re-appraisal of the Twin Deficit Hypothesis, Shaikh (2012) states that,

> it was confined to a static economy (a constant level of income) because, as they themselves point out, their adjustment process was unstable in the context of exogenous growth (p.129).

The adjustment process he is referring to is the partial adjustment process which has been the subject of this chapter. He then goes on to "generalize" their argument and their adjustment process to accommodate economic growth. He deals with two issues, growth of national income and the stability of the partial adjustment process. The first appears to arise from a misinterpretation of the target wealth variable, FA^*; he concludes that in a full stock equilibrium, $\Delta FA = 0 = \phi(FA^* - FA_{-1})$ so FA^* must be constant, and since $FA^* = \alpha YD$, then YD must be constant also. But this only holds in a full-stock equilibrium; out of equilibrium, when YD is varying, FA^* is varying also. It is α that is assumed constant, not FA^* and the confusion goes away if the variables are written with time subscripts, ${FA_t}^* = \alpha YD_t$.

Hence, if YD_t grows with time, ${FA_t}^*$ will also and convergence under the stock-flow norm will be to a steady-state rather than a stationary state. This chapter has considered the hypothesis that the flow ratios act as drivers of income through the multipliers; if the flow ratios are constant, then income will converge to a stationary state, but in a growing economy, the fiscal stance (G/θ) could be expected to grow in line with income since G will do so and θ tends to be quite stable. The trade ratio could be expected to grow in line with the world economy, assuming that import propensities for the domestic economy and the world economy are roughly stable. If the flow ratios are increasing, income will converge to a *steady* state.

5.4. The Convergence Process with Growth

It is true that the models in Godley & Cripps (1983) are, for the most part, constructed in such a way that they converge on a stationary equilibrium state with constant income, but this is for ease of exposition, not a logical requirement. Godley & Cripps (1983, p.58) briefly presents a steady growth model, but they revert to the constant-income presentation thereafter.

The second issue concerns the stability of the partial adjustment process with endogenous growth, a legitimate concern as the previous section demonstrates. But the issues of endogenous growth in these models does not exclude the possibility of growth altogether.

Martin (2012) also revisits the New Cambridge hypothesis in a reassessment of the aggregated private expenditure equation; he assumes a steady-state constant rate of income growth, g, and the relation governing the wealth-income norm becomes,

$$Lim(\frac{F}{Y^d}) = \frac{g}{1+g}\bar{\omega} \qquad \text{(eqn(7), p. 81)}$$

where $Lim(\frac{F}{Y^d})$ is the steady state financial surplus to disposable income ratio ($\Delta FA/YD$ in the notation used here), and $\bar{\omega}$ is the wealth-income norm (α in the notation used here).

Translated into the notation used here, in the steady state, $\Delta FA/YD = \frac{g}{1+g}\alpha$. This is saying that, *in the steady state*, the savings rate is constant at a fraction, determined by the growth rate, of the wealth-income norm. Figure 4.2.1 plots $\Delta FA/GDP$ for the US economy which could give an indication of $\Delta FA/YD$ and, while it clearly does not attain a steady state, the mean values are in a reasonable range of values that could be expected for $\frac{g}{1+g}\alpha$.

The conclusion is that the convergence process is equally applicable to a growth economy in which case convergence will be to a steady state rather than a stationary state. However, the simulations that follow will continue to assume a steady-state equilibrium for clarity, but the empirical models of chapter 6, being based on real-world data will necessarily be growth models.

5.5 The Convergence Process: Simulations

Having developed the three sector multiplier in section 5.2 and the linear difference equations in the previous section, simulations will now be run to explore their properties. In section 5.5.1, a simple simulation of a system with the three sectoral flow ratios and the multiplier expression from equation 5.7 will demonstrate the different convergence scenarios depending on the relative magnitudes of the fiscal stance and the trade ratio and the 'degree of exogeneity' of the sectoral expenditure flows. This will lead into the classification into 'surplus' and 'deficit' economies in section 5.6.

In section 5.5.2, computational solutions to the linear difference equations 5.12 and 5.14 are explored.

5.5.1 Simulation of the Multiplier Process

The simulations will serve to demonstrate three common scenarios determined by which of the flow ratios are fixed and which are able to adjust.

Twin Deficits: FS and **TR** fixed, convergence to **CFTR**

In this simulation, the *fiscal stance* (FS) and the *trade ratio* (TR) are fixed which effectively means that government expenditure and exports are exogenous; consequently, it is private expenditure that adjusts in such a way that national income converges to the CFTR (the private sector balance condition). Starting from a full-stock equilibrium where $Y = G/\theta = X/\mu$ (and since two sectors are in balance, the third must be also), a 'stimulus' is applied by increasing the fiscal stance, and the ensuing convergence is shown in the top panel of figure 5.5.1.

But this doesn't lead to a full-stock equilibrium as the lower panel illustrates. Due to the rise in the fiscal stance, government spending exceeds taxation so government debt is increasing; the rise in income increases imports leading to a current account deficit so foreign reserves are decreasing. If income were to converge to the fiscal stance, the increased income would lead to increased tax receipts and eliminate the budget deficit, but the increased income would also increase imports leading to a further deterioration of the current account. This is the classic 'twin deficit' situation (page 35), which is characterised by a situation where $G/\theta > X/\mu$. The private sector's financial assets are roughly stable and the government deficit is being financed by the foreign sector. As long as neither of these ratios is able to adjust the situation will continue as long as foreign reserves last.

Balance of Payments Constrained Growth: TR fixed, **FS** accommodates, convergence to **TR**

In this scenario, the trade ratio (TR) is fixed (after an initial shock). The top panel of figure 5.5.2 shows the system subjected to a shock to exports in period 20 which lowers the trade ratio, after which it is unable to adapt further, imitating the situation of a foreign exchange constrained economy. Hence, it is private expenditure and the fiscal stance which must adapt causing income to decline and converge to the new lower trade ratio.

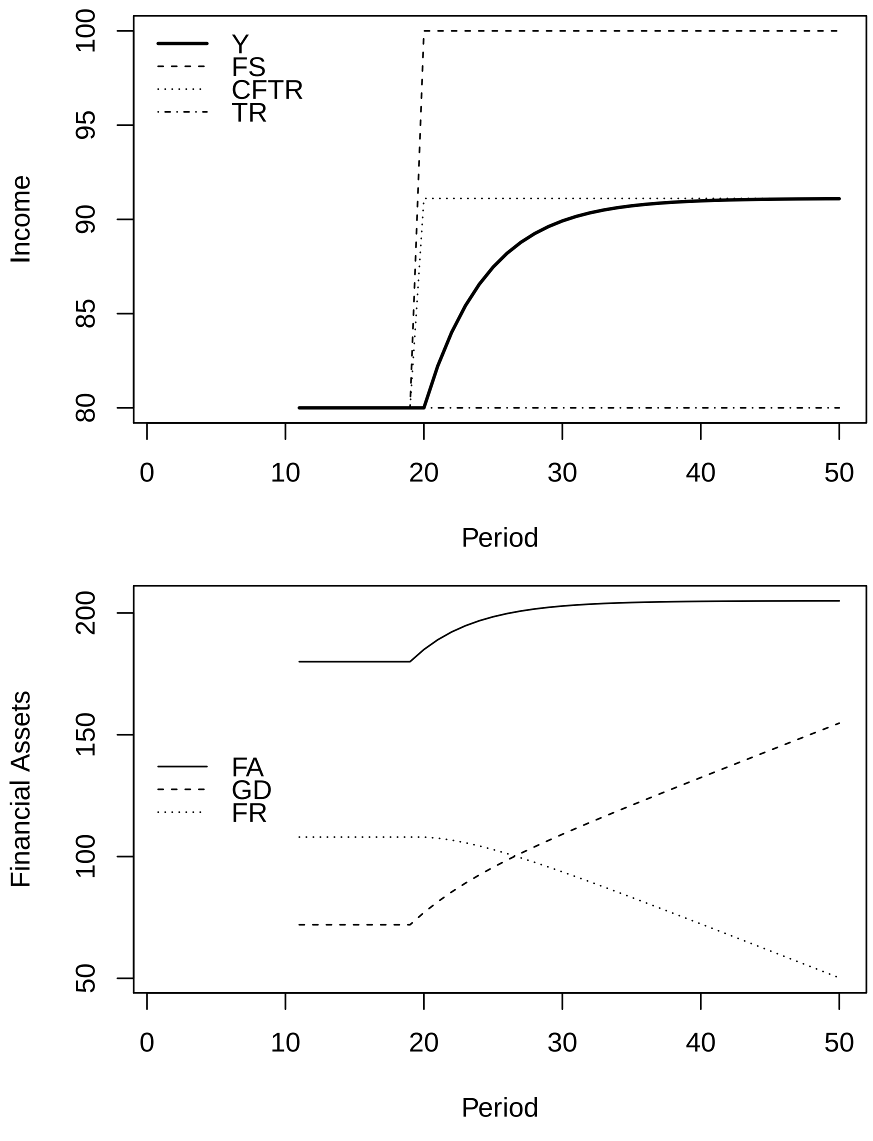

Figure 5.5.1: Convergence of the Three Sector Model: FS and TR fixed.
Based on simulated data.

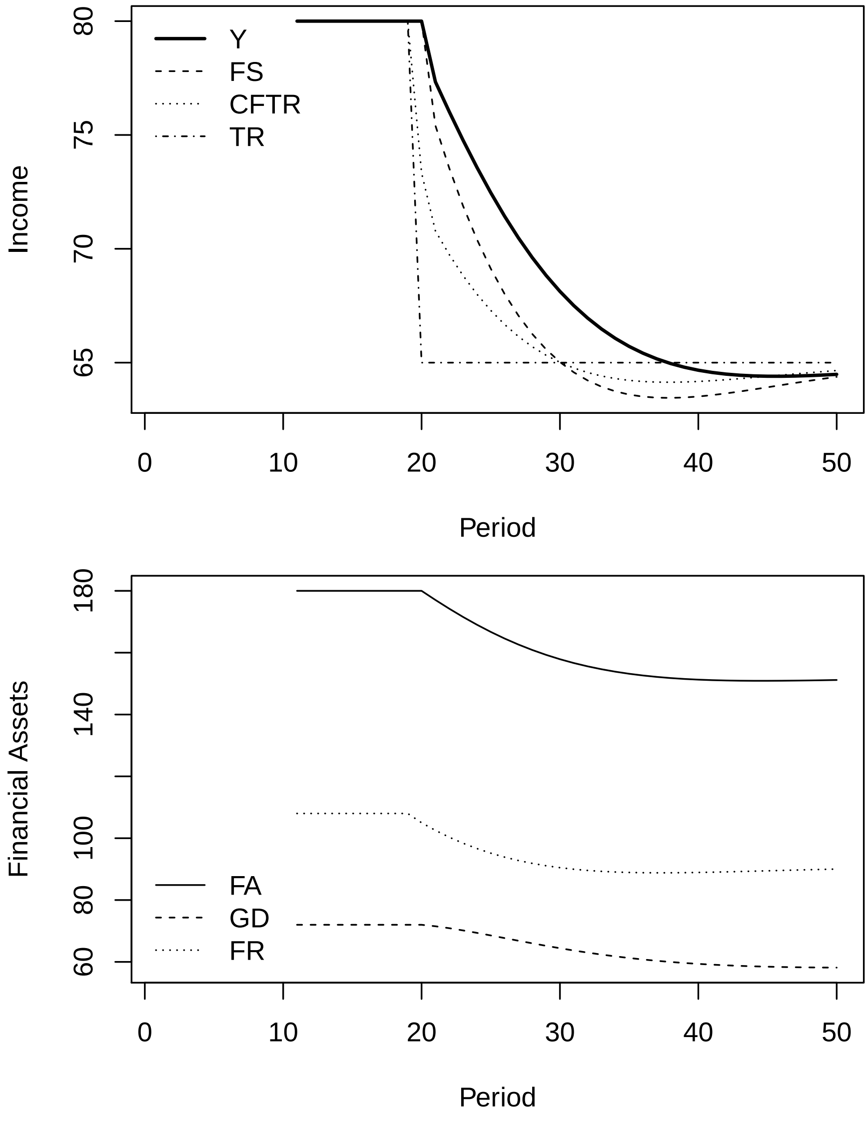

Figure 5.5.2: Convergence of the Three Sector Model: TR fixed, FS and PX free to adjust

Based on simulated data.

In this scenario, since there are two balance conditions that are able to adapt, the system converges to a full stock equilibrium, with lower but stable levels of all stocks and a lower level of national income.

Maastricht Criteria: FS fixed, **TR** accommodates, convergence to **FS**
Finally, if the government's budget is constrained so that the fiscal stance is fixed, but private expenditure and the trade ratio are free to adapt, the system converges to the fiscal stance. Figure 5.5.3 shows the system subjected to a negative shock to the fiscal stance after which it is unable to adapt further. In this case, income and the trade ratio converge on the fixed fiscal stance. Again, since there are two sectors which can adjust, the system eventually settles into a full-stock equilibrium.

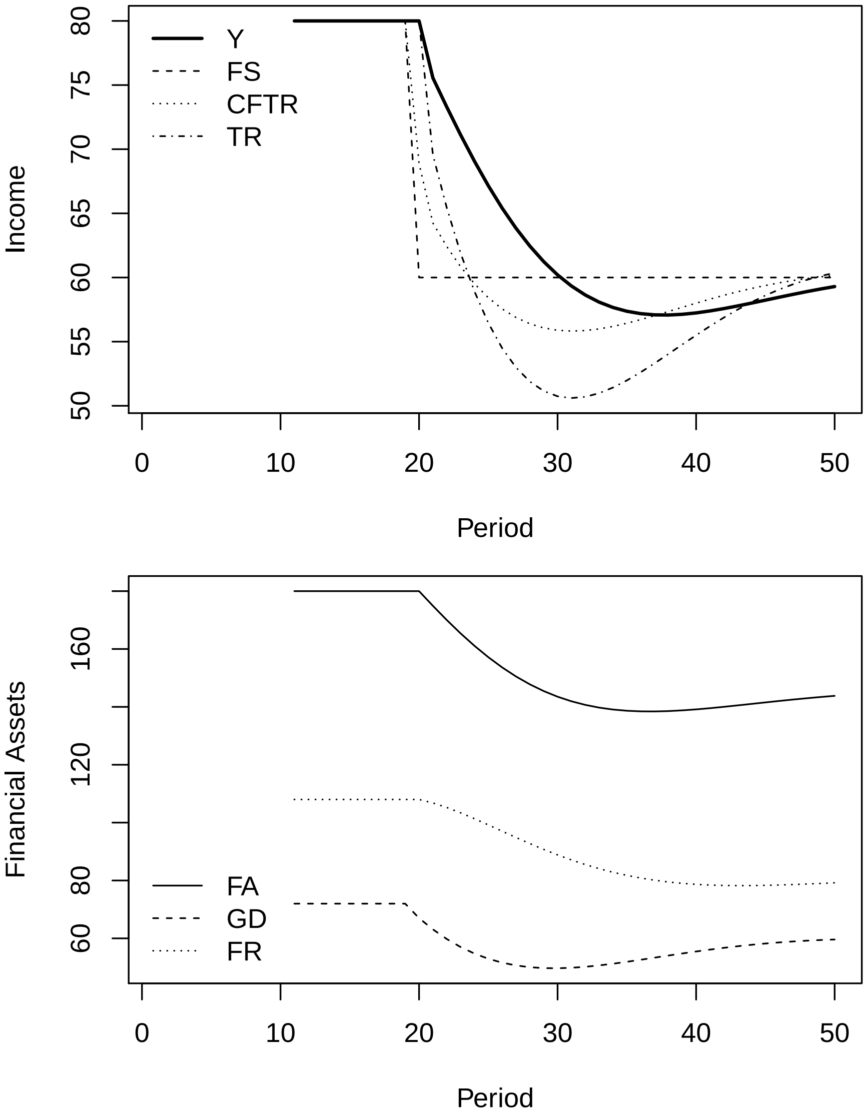

Figure 5.5.3: Convergence of the Three Sector Model: X free to adjust
Based on simulated data.

5.5.2 Simulation of the Linear Difference Equations

Section 5.3 derived a linear difference equation (eqn 5.14) for the stocks of the three sector model, but could not provide an analytical solution because of the complexity of the coefficient matrix which was a product of three matrices, one consisting of terms in θ and μ, the second containing terms in the stock-flow norms and the adjustment factors and the third containing just the adjustment factors. This section provides a computational solution to the equation.

Equation 5.14 is a homogeneous linear difference equation and doesn't have a steady-state solution. Consequently, depending on the eigenvalues of the coefficient matrix, the values of the stocks will either grow without limit for eigenvalues greater than one, or spiral in to zero for eigenvalues less than one. Another possibility was suggested (p.255) that the eigenvalues might vary around a value of one, leading to an alternation of growth and contraction of stocks corresponding to the business cycle. A numerical solution in which very subtle variations in the values of the speed of adjustment factors (ϕ,ψ and ξ) caused a pattern of oscillations in the values of the eigenvalues as shown in figure 5.5.4.

The top panel shows part of the evolution of the three eigenvalues of the coefficient matrix for small variations in the speed-of-adjustment factors (ϕ,ψ and ξ). The lower panel shows the evolution of simulated stock values for the selected parameter combinations. This is a very small and carefully selected sample from a potentially very large space; the eigenvalues are not this 'well-behaved' throughout the whole space. Eigenvalues 2 and 3 vary little, but eigenvalue 1 varies wildly for some parameter combinations, there are complex dynamics at work. However, the purpose is merely to show that the linear difference equa-

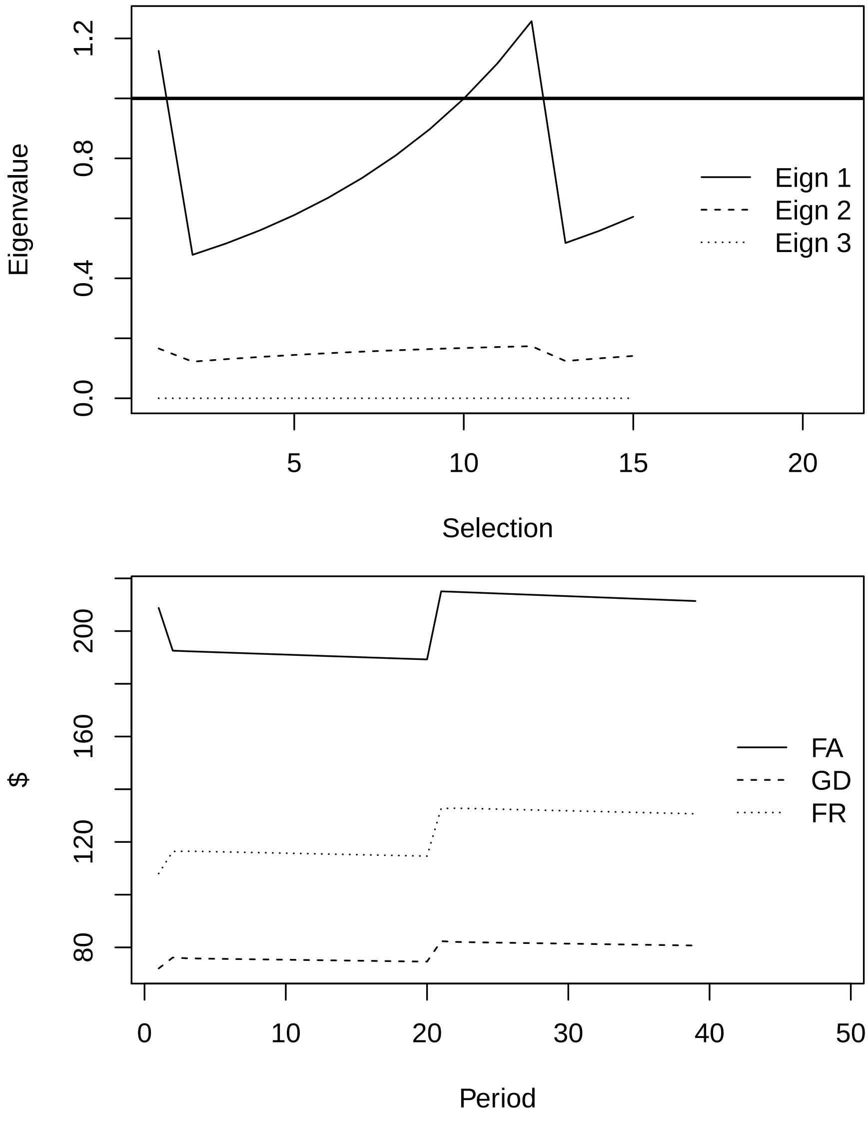

Figure 5.5.4: Solution to the Linear Difference Equation for Stocks in the Three Sector Model.

Based on simulated data.

tion 5.14 incorporating partial adjustment processes incorporating stock-flow norms exhibits credible disequilibrium dynamics for a wide range of parameter combinations.

The concept of disequilibrium dynamics was introduced earlier in the context of complex adaptive systems (section 3.1.1, p.121), the reason they are considered 'credible' here is that they are triggered just by small perturbations in the speed-of-adjustment factors, something that could be expected to occur routinely in a real system. The speed-of-adjustment factor determines how much of the target-actual gap in stocks will be 'corrected' in each period. It's hard to believe that this would be a fixed factor, and entirely credible to suppose that it would fluctuate within limits from period to period, generating a rather turbulent pattern in the stocks and flows in the system.

The computational solution to the linear difference equation will not be pursued further here, leading as it does into areas of complex non-linear dynamics, but the study of the dynamic behaviour of this system will be continued in section 6.4.2 where it will be formulated into a VAR model.

5.6 Surplus and Deficit Economies

This section interprets the results of the simulations under the multiplier in section 5.5.1 to propose a classification of economic systems as *surplus*, i.e. those that are likely to run budget and current account surpluses, or *deficit*, those that are likely to run both budget and current account deficits. In the simulations of section 5.5.1, three common scenarios out of the many possible were illustrated; the outcome seems to depend on two key factors, firstly the relationship between the fiscal stance and the trade ratio, and secondly, which of them is fixed.

Considering all three sectoral balance conditions together, it's reasonable to expect that μ will be a rather stable structural parameter. Historical data shows that for the US economy, this has been relatively stable but with a gradual uptrend over a long period (discussed in section 4.1.2.2, p.176). Likewise the level of exports X is effectively exogenous being dependent on the level of demand in the world economy. On the other hand, θ is a policy variable and can be changed by decisions of the government although in practice, it too is relatively unchanging over long periods. The most changeable of the variables in the balance conditions is G, the level of government expenditure, which will adapt through the 'automatic stabilisers' to the level of economic activity. Various possibilities for these conditions are plotted in figure 5.6.1.

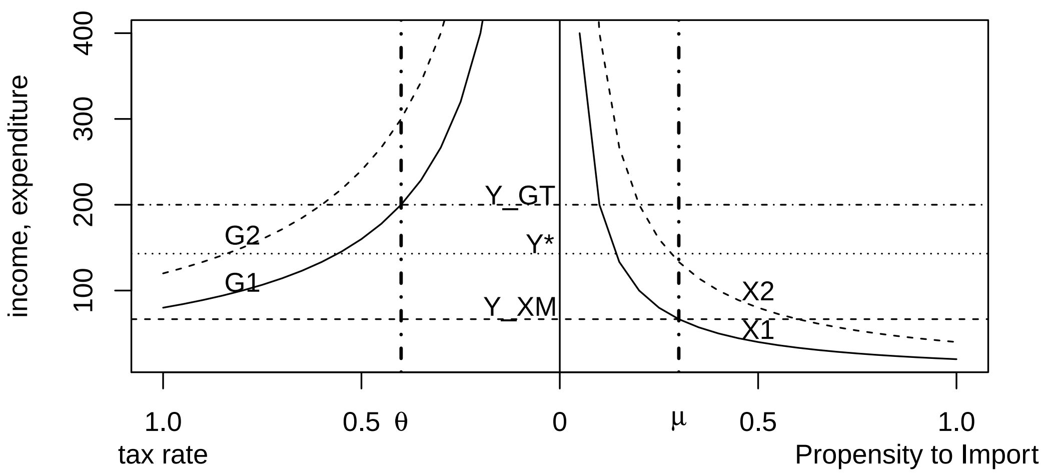

Figure 5.6.1: Balance Conditions for a three sector economy

The right hand panel shows the condition for external balance and plots income/expenditure on the vertical axis against μ on the horizontal axis. The heavy vertical line represents the 'normal' value of μ given the current structural setup of the economy. Successive curves in this panel plot X/μ with various levels of exports and $X_2 > X_1$. Where these curves intersect the line of constant μ gives the income level for external balance, Y_{XM}. If income is greater than the trade ratio, imports exceed exports and the economy has a current account deficit.

Similarly, the lefthand panel plots income/expenditure on the vertical axis against θ on the horizontal axis. The heavy vertical line shows the 'normal' level of θ. The curves represent G/θ at various levels of government expenditure, with $G_2 > G_1$. Where they intersect the θ line gives the level of income for public sector balance, Y_{GT}. If income is greater than the fiscal stance, taxes exceed government expenditure and the economy has a budget surplus. These income levels will only be the same when both the public and foreign sectors are simultaneously in balance (almost never).

The situation where the fiscal stance is greater than the trade ratio ($G/\theta > X/\mu$) characterizes a 'deficit economy', and conversely, a trade ratio that is greater than the fiscal stance ($X/\mu > G/\theta$) is characteristic of a 'surplus economy'. These characterizations depend on the position of national income Y in relation to the two flow ratios, as can be seen from the listing of all the possibilities in tables 5.6.2 and 5.6.1. The preferred situation for any economy is a private sector surplus, the last two lines in both tables. The alternative of a private sector deficit leads to mounting private debt and eventually becomes unsustainable. Looking at the last two lines for a deficit economy (table 5.6.2), it can be seen that a public sector deficit is unavoidable, and a current account deficit can only be avoided if income is lower than the trade ratio. The same observations on table 5.6.1 show the converse, where the private sector is in surplus, the current account is also, and if income exceeds the fiscal stance, there is also a budget surplus.

Note that this is simply a classification based on the three balances of the national income accounts and is not saying that any particular scenario is good or bad, but clearly some are going to be more sustainable than others – as exemplified by the scenarios of 'balance of payments constrained growth' and the 'twin deficits' in section 5.5.1.

Surplus Economy: Trade Ratio exceeds Fiscal Stance ($Y_{XM} > Y_{GT}$)

	Private Sector	Public Sector	Foreign Sector	
$\mathbf{Y} > Y_{XM} > Y^* > Y_{GT}$	$-$	$+$	$-$	
$Y_{XM} > \mathbf{Y} > Y^* > Y_{GT}$	$-$	$+$	$+$	
$Y_{XM} > Y^* > \mathbf{Y} > Y_{GT}$	$+$	$+$	$+$	<– Twin Surpluses
$Y_{XM} > Y^* > Y_{GT} > \mathbf{Y}$	$+$	$-$	$+$	

Table 5.6.1: Relation of Y to Flow Ratios for a Surplus Economy
Y_{GT}: Fiscal Stance; Y^*: CFTR; Y_{XM}: Trade Ratio
$+$: Surplus; $-$: Deficit

The third line of the table deserves some explanation; it says that all three sectors are running a surplus at the same time which doesn't seem possible. But an entry of '+' in the third column of table means that $Y_{XM} > Y$ which means that $X > M$; so the domestic economy is running a surplus against the rest of the world, or the foreign sector is running a deficit. In terms of the national income accounting identity, $(S - I) + (T - G) \equiv (X - M)$, the s̀urplus' against the rest of the world is the sum of the savings of the domestic sectors.

Once the basic orientation of the economy as 'surplus' or 'deficit' has been decided, the second key determinant of its subsequent trajectory, will depend on whether the two flow ratios are fixed or flexible, in other words, which of the main expenditure items, exports X or government expenditure G are treated

Deficit Economy: Fiscal Stance exceeds Trade Ratio ($Y_{GT} > Y_{XM}$)

	Private Sector	Public Sector	Foreign Sector	
$\mathbf{Y} > Y_{GT} > Y^* > Y_{XM}$	$-$	$+$	$-$	
$Y_{GT} > \mathbf{Y} > Y^* > Y_{XM}$	$-$	$-$	$-$	
$Y_{GT} > Y^* > \mathbf{Y} > Y_{XM}$	$+$	$-$	$-$	<– Twin Deficits
$Y_{GT} > Y^* > Y_{XM} > \mathbf{Y}$	$+$	$-$	$+$	

Table 5.6.2: Relation of Y to Flow Ratios for a Deficit Economy
Y_{GT}: Fiscal Stance; Y^*: CFTR; Y_{XM}: Trade Ratio
$+$: Surplus; $-$: Deficit

as exogenous.

If the trade ratio is fixed — exports exogenous and μ unable to adjust — the national income will tend to converge on the trade ratio as in figure 5.5.2. The trade ratio is likely to be fixed, or at least slow-moving, for most economies since demand for exports is largely outside their control and changes to μ are likely to happen only over extended periods of time. Some economies are able to sustain current account deficits for long periods (the US has only had two quarters with a current account surplus since 1983, which was also the last time the UK had a current account surplus). The current account deficit of an economy must be matched by a surplus on the capital account, meaning that foreigners are willing to hold debt or to buy and hold assets in the deficit economy. This is clearly the case for the US which issues the world's currency and whose treasury bills are considered the world's risk-free asset. The financial centre of the City of London (and perhaps also the London property market) serve the same purpose for the UK. However, for many countries, especially developing economies, international capital is not so readily available, which is the situation described as *Balance of Payments Constrained* growth (Thirlwall

2012).

Alternatively, if it is the budget constraint that is binding, national income will converge on the fiscal stance as in figure 5.5.3. Perhaps the obvious example of this scenario is Eurozone's stability and growth pact where EZ countries are bound to limit budget deficits to a maximum of 3% of GDP. The simulation in figure 5.5.3 shows the economy settling on a full stock equilibrium defined by the fiscal stance, but it assumes that the trade ratio is flexible and able to adapt. As discussed in the previous paragraph, this is generally unlikely, and even if the trade ratio is able to adapt, it is likely to be a slow process.

In cases where both constraints are binding, national income will converge on the private sector balance, as in the simulation in figure 5.5.1. This does not represent a full stock equilibrium, so economies in this situation will have continuing sectoral imbalances. This seems to be the most common situation as the examples from various European economies will show in the next section.

5.7 Examples of Surplus and Deficit Classification

This section uses data taken from the national accounts of selected European countries to illustrate some of the effects described in the previous section. Time series for the fiscal stance, the trade ratio and the CFTR are co-plotted with national income in figures 5.7.1 to 5.7.3. The relationship between the fiscal stance and the trade ratio is used to classify the economies into 'surplus' and 'deficit' economies, following the pattern in tables 5.6.2 and 5.6.1, and a third category 'mixed' which don't exactly fit either pattern.

In each case the ratios have been normalised with respect to the CFTR (the private sector balance condition) which forms the horizontal dotted line in the centre of the plot. If GDP (heavy black line) is above the CFTR line, the private sector is in deficit. If the green line (foreign sector balance) is above the red line (public sector balance), the economy is classified in the surplus category as can be seen in figure 5.7.1 for Germany, Denmark, Ireland and the Netherlands. Sweden (not shown) is also a surplus economy. Deficit economies have the public sector balance condition (red line) above that of the foreign sector (green line) as can be seen in figure 5.7.2 for Greece, Finland, France and the UK. Mixed economies have attributes of each category as is the case of Austria, Belgium, Spain and Italy in figure 5.7.3; Portugal (not shown) is also in this category.

The surplus economies all display a similar pattern, income tends to converge to the fiscal stance (Y_{GT}); it is generally less than the trade ratio (Y_{XM}) and the $CFTR$, meaning steady surpluses in the current account and the private sector balance. The income line oscillates around the fiscal stance, indicating that these economies are running small budget deficits and occasional surpluses (alternating between lines 3 and 4 in table 5.6.1, p.270). They all had budget deficits around the period of the financial crisis — very noticeable in the case of Ireland — but income and the fiscal stance are re-converging in the post-crisis period to the standard pattern.

The deficit economies display a different pattern, the classic pattern for a deficit economy is represented by the UK. The fiscal stance (red line) runs consistently along the top indicating a permanent budget deficit, income (solid black line) tracks just below the CFTR (dotted line) indicating a small private sector

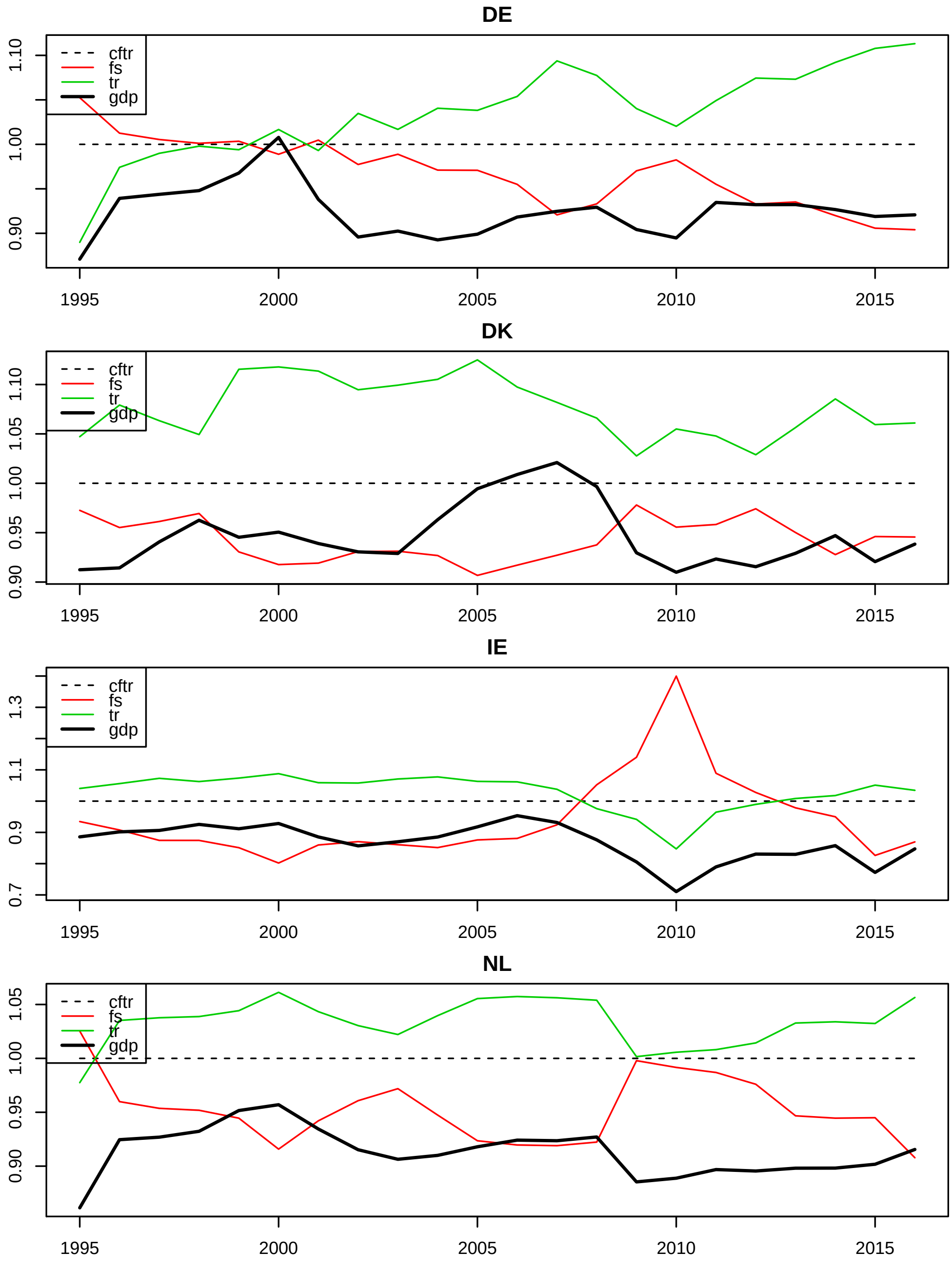

Figure 5.7.1: Balance Conditions for various European 'surplus' economies
DE: Germany; DK: Denmark; IE: Ireland; NL: Netherlands.
Data Source: Eurostat Table *nasa_10_nf_tr* (see section 3.2.2)

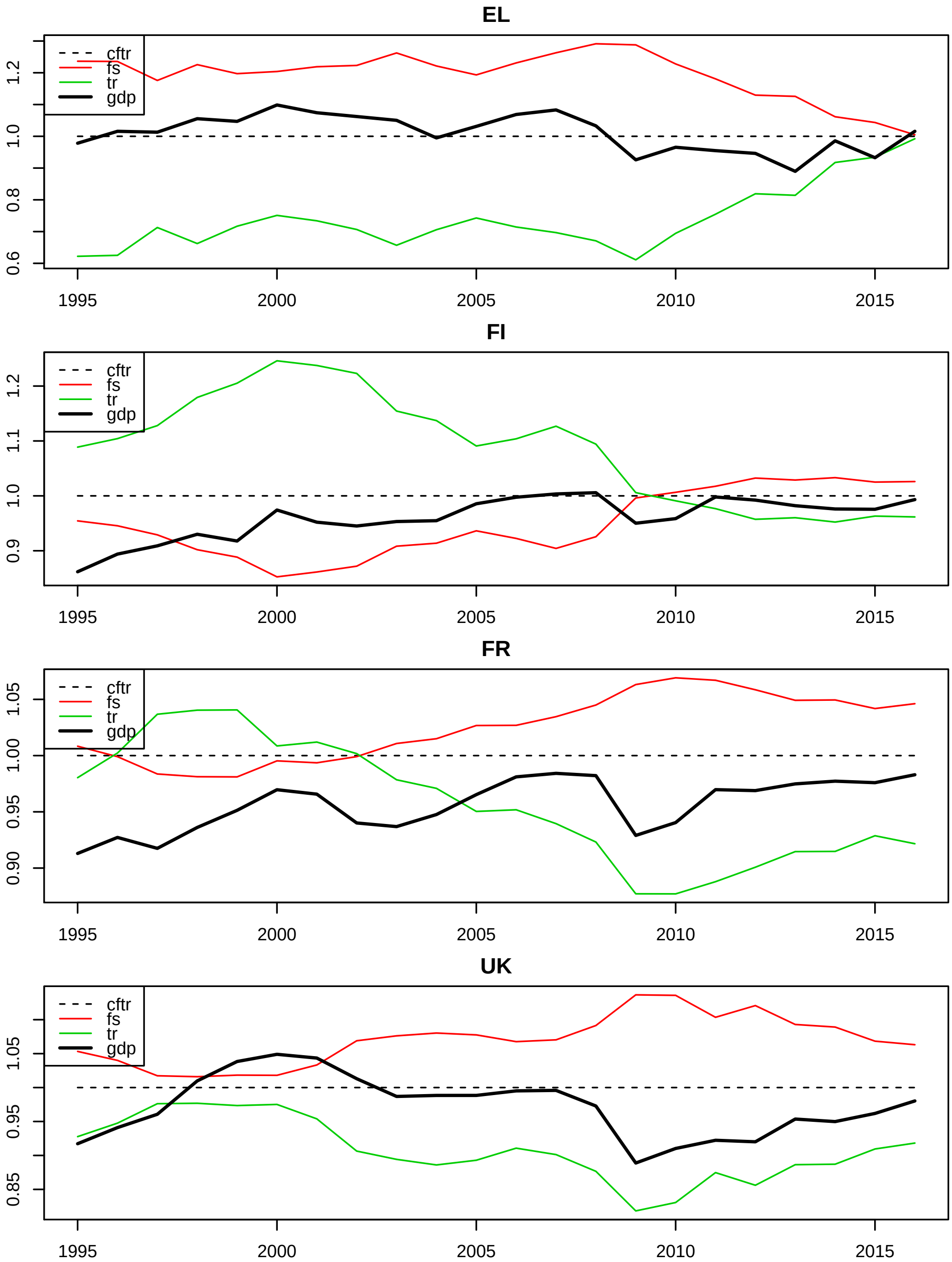

Figure 5.7.2: Balance Conditions for various European 'deficit' economies
EL: Greece; FI: Finland; FR: France; UK: United Kingdom.
Data Source: Eurostat Table *nasa_10_nf_tr* (see section 3.2.2)

surplus and finally the trade ratio (green line) runs along the bottom, indicating a permanent current account deficit. This is the standard *twin deficits* situation discussed earlier (p.35). The UK deviated briefly from this pattern around the year 2000 when the government ran a budget surplus for a short time accompanied by a private sector deficit in the period leading up to the dotcom bubble. They were pursuing similar policies to the Clinton administration in the late 1990s discussed earlier on page 166 and criticised by Godley as one of the *Seven Unsustainable Processes* (Godley 1999a). Apart from that brief interlude, the UK has followed the classic deficit pattern, even in the post-crisis period.

The other countries shown are adhering to this pattern now but have all shown different patterns in earlier periods. France ran fairly consistent current account surpluses until the early 2000s, about the time of the introduction of the euro, but was not a classic surplus economy because of its persistent budget deficits which were matched by a private sector surplus. In the early 2000s it switched to a classic twin deficits pattern.

Finland switched from being a surplus to a deficit economy around the time of the crisis and now displays a classic 'twin deficits' pattern although the imbalances appear to be small compared to other countries.

Greece is a special case — in the pre-crisis period it was running three deficits, on the budget and the current account and even had a private sector deficit for much of the period (row 2 in table 5.6.2). This shows that, throughout much of this period both the public and the private sectors were borrowing from abroad. Since the crisis, all three ratios are converging on the CFTR, in a similar way to the simulated scenario in figure 5.5.1 in which both the fiscal stance and the trade ratio were binding, with the difference here in the case of Greece that FS and TR are not fixed but converging towards each other under the austerity of the post-crisis period.

In the mixed economies, national income lies below all of the flow ratios and is not converging to any of them. They all have in common large private sector surpluses, accompanied by current account surpluses and budget deficits. The private sector surplus means that the private sector is acquiring both government and foreign debt. Referring to tables 5.6.2 and 5.6.1, Austria and Italy, match the pattern in line 4 of table 5.6.1, the surplus economies, while Belgium and Spain match the pattern in line 4 of table 5.6.2, the deficit economies. If income were to rise relative to the flow ratios, Austria and Italy would revert to surplus economies while Belgium and Spain would become deficit economies.

Looking back to Godley's assertion that income will converge to a steady state under the action of the stock flow norm, it appears from these examples that the different types of economies converge to different states implying that different norms are active — in the language of the previous section, which of the expenditure items is being treated as *exogenous*. The surplus economies appear to conform to the pattern of a fixed fiscal stance, i.e. government expenditure exogenous. The deficit economies conform to the pattern in figure 5.5.1, i.e. fiscal stance and trade ratio both binding and income converging to the private sector balance. This is the twin deficits scenario. Finally, the mixed economies may have a deficit structure (FS > TR) or a surplus structure (TR>FS) but differ from the deficit and surplus economies in the respect that the income line is below all the other ratios, leading to large private sector

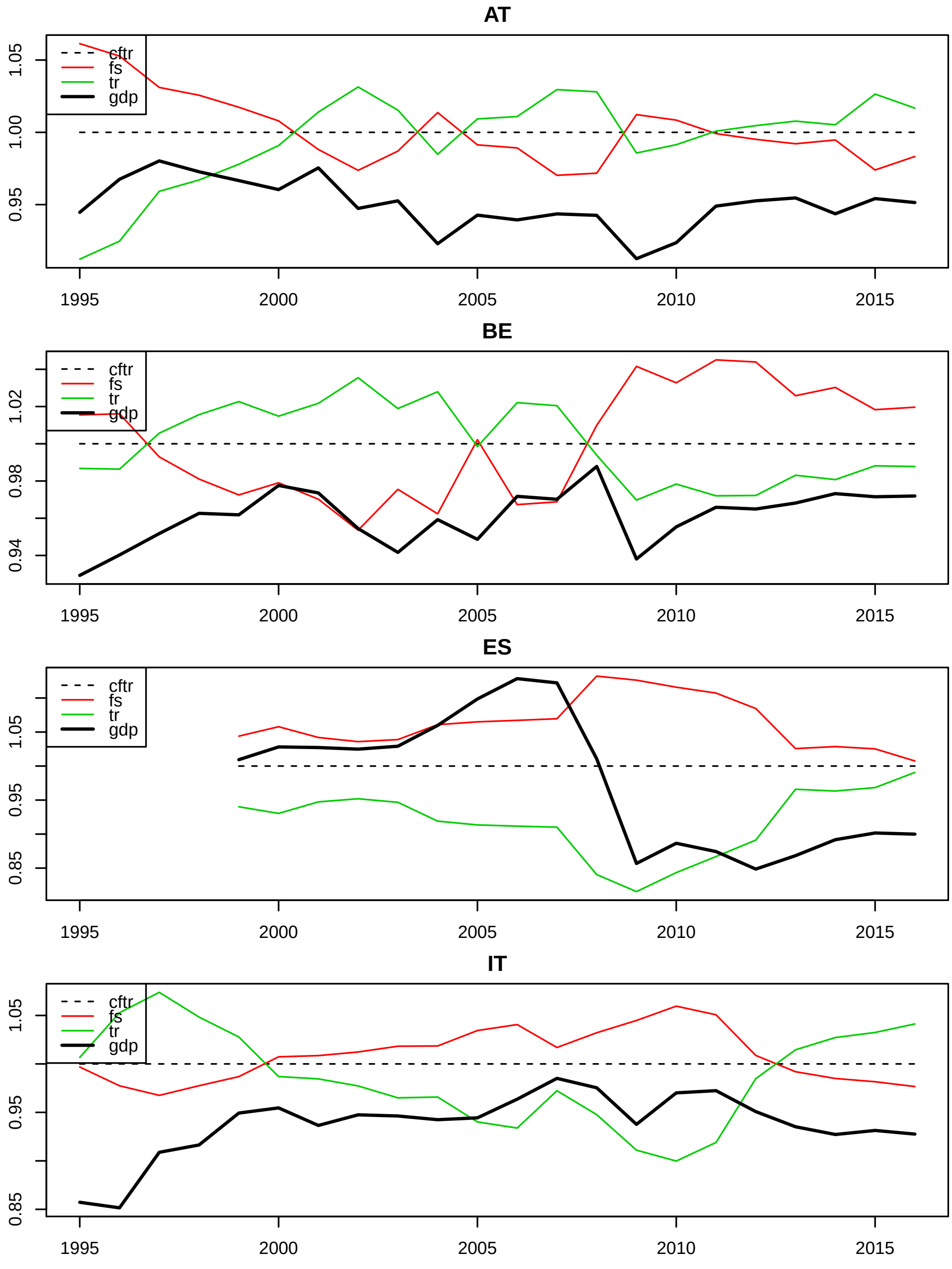

Figure 5.7.3: Balance Conditions for various European 'mixed' economies
AT: Austria; BE: Belgium; ES: Spain; IT: Italy.
Data Source: Eurostat Table *nasa_10_nf_tr* (see section 3.2.2)

surpluses with budget deficits and current account surpluses (line 4 in tables 5.6.2 and 5.6.1). If income were to rise relative to the other ratios, they would revert to classic surplus or deficit economies, depending on their structure. Whether this would be in their best interests, particularly in the case of Belgium and Spain, would require deeper investigation; they would be trading their large private and trade surpluses for a lower budget deficit. In the case of Belgium and Spain, the surpluses could be totally eliminated while the budget deficit would remain; in the case of Austria and Italy, the budget deficit could be eliminated in exchange for reduced surpluses. Whether this implication of the plots could be realized would require more precise modelling of each individual economy and an understanding of why income is not converging in the expected way. It's possible that income is being suppressed by contractionary fiscal policy for fear of allowing deficits to exceed Eurozone-imposed limits. The analysis suggests that allowing income to rise would actually reduce deficits by increasing the tax take.

5.8 Summary and Conclusions on Ratio Analysis in Economic Dynamics

This chapter has studied Godley's assertion about the dynamics of an economy cited in his address to the Keynes centenary conference "Real demand, output and employment are determined via a multiplier process by the fiscal and monetary operations of the government and by foreign trade performance..." (Godley 1983). Nothing has been said here about the monetary operations of the government, the focus has been entirely on the way that the fiscal operations, in the guise of the *fiscal stance* ($FS = G/\theta$) and the foreign trade performance, in the form of the *trade ratio* ($TR = x/\mu$) act as injections (or leakages) to the private sector through a *complete multiplier* to determine national income subject to *stock-flow norms* acting in each sector. The flow ratios, i.e. the FS and the TR, and the stock-flow ratios were introduced in chapter 4 with reference to empirical data from the Integrated Macroeconomic Accounts of the US (F.R.B. 2018).

The first test of this hypothesis was to establish whether there is a long-term relationship between the flow ratios and the national income, which involved the estimation of a Johansen VAR model between FS and Y and also between TR and Y. Cointegration entails Granger-causality, if two time series are cointegrated, there must be Granger-causality in one direction or the other (or both); this is the *Granger Representation Theorem*. To determine in which direction the 'causality' runs, Granger tests between the flow ratios and national income were conducted. This showed that, for up to 8 time periods from a 'shock', it is changes in the fiscal stance that are 'Granger-causing' changes in national income, but changes in national income are not 'Granger-causing' changes in the fiscal stance, implying that the changes in the fiscal stance *lead* changes in income.

Godley's centenary conference presentation dealt with a model of a closed economy and showed how income would converge to the fiscal stance under these circumstances. Section 5.2 extended this to an open economy, based on the New Cambridge three balances identity (section 2.2.1.1). This mainly consisted of developing a *complete multiplier* following the example of Leite (2015), constructed from partial adjustment processes for each sector incorporating the sectoral stock-flow norms, in such a way that the resulting multiplier expression (equation 5.7) embodies the intrinsic stock-flow dynamic of the economy. This is due to the fact that the numerator of the expression, which effectively becomes the *multiplicand* to the multiplier, and which contains the 'autonomous' elements, or income-independent quantities, consists entirely of the opening values of the stocks of the three sectors.

An equivalent formulation of this dynamic was developed in section 5.3 in the form of linear difference equations. By combining the partial adjustment expressions for each sector with the target values implied by the stock-flow norms, expressions for the sectoral expenditure flows were obtained in terms of the starting values of the stocks, effectively encapsulating the first step of the stock-flow dynamic — "*opening stocks determine flows*". Putting these three expressions together in a matrix format resulted in equation 5.12, and by adding the second step of the stock-flow dynamic — "*flows update stocks*" — completed the cycle, resulting in equation 5.14. The fact that all variables in these equations are endogenous means that they are mathematically unstable. They model the *disequilibrium dynamics* of the economy but, because there are no exogenous variables, there is no steady state.

Section 5.5 set out to explore through computational simulations the multiplier expression and the linear difference equations developed in the previous sections. The simulations of the multiplier process (subsection 5.5.1) aimed to replicate the convergence of national income to the flow ratios under the action of the multiplier (incorporating the stock-flow norms). Whereas in Godley's two sector closed economy, income converged to the fiscal stance, here different scenarios arose, depending on which of the flow ratios was 'binding', in other words which expenditure item was assumed exogenous. The first simulation revealed that, with both ratios binding so that only private expenditure was able to adjust, convergence was to the private sector balance (CFTR), but did not result in a full stock equilibrium. There were continuing current account and budget imbalances, whether surpluses or deficits depended on the structure of the economy — FS exceeds TR, or vice versa — which was subsequently developed in section 5.6 into a classification of 'surplus' and 'deficit' economies. The following simulations explored cases where one ratio was binding but the other was flexible to adapt, showing that income converged to whichever ratio was binding. In these cases, all three ratios and income converged, resulted in a full-stock equilibrium.

The simulation of the linear difference equations in subsection 5.5.2 looked for a computational solution to equation 5.14 which, as noted above is mathematically unstable. The strategy adopted was to search the parameter space for combinations of the stock-flow norms and the *speed-of-adjustment factors* yielding values of the largest eigenvalue (λ_1) of the coefficient matrix very close to one. If $\lambda_1 > 1$, stocks are expanding, simulating a growth situation, whereas if $\lambda_1 < 1$, stocks are contracting, simulating a recession situation. If λ_1 gets very far above (or below) one, the growth (or contraction) becomes explosive. Starting from a situation where $\lambda_1 \approx 1$, and making small variations to the speed-of-adjustment factors, the simulation was able to replicate the situation of the economy moving from growth $\lambda_1 > 1$ to recession $\lambda_1 < 1$ and vice versa.

Godley argued that the two sector, closed economy would converge on the fiscal stance. The question of how convergence would proceed in a three sector economy was addressed by the simulations of the multiplier process, and the outcome appeared to depend on two things, firstly whether or not the fiscal stance exceeds the trade ratio, and secondly, which of them is 'binding'. The first condition leads to a classification into *surplus economies*, those tending to run current account and budget surpluses and *deficit economies*, those tending to run current account and budget deficits. These classifications were explained in section 5.6 and illustrated by examples of European economies based on Eurostat data in section 5.7.

Having summarized the work of this chapter, what conclusions can be drawn? Firstly, the development and simulation of the complete multiplier was able to demonstrate Godley's economic dynamic whereby income converges to the fiscal stance under the constraints of the stock-flow norms, supporting the conclusion that this is indeed a plausible and viable explanation for how real economic systems evolve. If Godley's assertion is treated as a hypothesis, the results relating to the multiplier has failed to refute it.

The multiplier and Linear Difference Equation formulation are equivalent representations and both provide a plausible mechanism for Godley's economic dynamic. In the case of the Linear Difference Equations, their instability limited the extent to which these could be explored, but the modest simulations undertaken encourage the conclusion that such fully endogenous systems offer a way of understanding how real economic systems evolve. It is fully supportive of the view of an economy as a *complex adaptive system*, in particular in this case, where system parameters are seen as able to vary within some defined limits, rather than having fixed values. The specific example used here was the variation of the speed-of-adjustment parameters in the partial adjustment processes, small changes to which could move the stocks in the three sector model from a growth trajectory to a contractionary one.

The finding from the simulations that the relative magnitude of fiscal stance and the trade ratio determine whether an economy is likely to run surpluses or deficits offer further support to Godley's assertion that the flow ratios are a determinant of the level of national income and, by extension output and employment. The flow ratios, rather than being neutral, clearly aid in understanding the evolution of national income. From this observation, a neat and consistent classification scheme for *surplus* and *deficit* economies was devised which can be a practical aid in highlighting certain trends, for example, the deterioration in France's foreign trade performance following the introduction of the euro.

The importance of the relationship between the fiscal stance and the trade ratio for overall economic outcomes was pointed out by Godley & Cripps (1983, p.296) and is discussed in Lavoie (2014, p.516), but is limited there to a discussion of the twin surplus - twin deficits scenario, the taxonomy developed here is more comprehensive. Caldentey (2007) develops a full SFC model of the CARICOM (Caribbean Community) countries which shows that their recent economic development, characterized by low growth, government and current account deficits, and mounting stock debt levels, can be explained by the relationship between fiscal and foreign trade performance — the fiscal stance and the trade ratio. The model highlights the binding character of the external constraint and links this with insights from the 'Balance of Payments Constrained Growth' literature to provide an alternative[2] view of the economic possibilities of these economies.

[2]...alternative to the Washington Consensus.

The conclusion from these logical analyses is that, under Godley's assumption of partial adjustment processes governed by stock-flow norms, the twin deficits syndrome results in economies dominated by a single partial adjustment process, that fully stable dynamics result from the assumption of two partial adjustment processes, and that dynamics consistent with a non-fixed parameter CAS view of the macroeconomy results from the simultaneous action of three partial adjustment processes. Of course, demonstrating that these dynamics result from Godley's assumption does not prove that the assumption is correct or that stock-flow norms are indeed the stabilising tendency in a macroeconomy, there are other possible stabilising processes which could be at work; but equally, the results do not call the assumption into question.

Chapter 6

The Three Sector Model with Aggregated Private Sector

In this chapter a stock-flow model is developed to apply the principles presented in the previous two chapters, that is, to study the dynamic interaction of the flow ratios and the stock-flow norms and their macroeconomic impact. The model to be presented is a highly aggregated one with just the three main sectors — private, government and the rest of the world — a single stock for each sector — net financial assets — and consequently, a single stock-flow norm per sector. The purpose of such a highly aggregated model is to produce the simplest possible model in which to explore the dynamics of the flow ratios and the stock-flow norms. With an aggegated private sector, flows like consumption and investment are not inter-sectoral flows, they are internal to the private sector and will be aggregated into a single flow, private expenditure, as in the New Cambridge model. Similarly, the balance sheet shows only inter-sectoral commitments – government debt, foreign borrowing/lending and the net assets of the private sector. Changes in the capital stock play no part in the model since investment is embedded within the private expenditure flow. This could be described as a 'black box' model, it looks at the macroeconomy from the outside, much of the detail is concealed at this level of aggregation; it may be able to answer questions about *what* happens, but to understand *how* and *why* requires progressive disaggregation of the model to reveal more and more of its inner workings. But the results obtained at this level will still be binding on those disaggregated models.

The structure of the model is presented in section 6.1 and is fully populated in section 6.2 with data from the US IMA from 1960 to 2016, with the result that each of the variables of the model is represented by a time series. Before embarking on the estimation of the populated model, a ratio analysis of the US economy is carried out to position it within the classification derived in section 5.6 of the previous chapter. Since the model time series are normally non-stationary, relations between them will be explored through cointegration analysis. Vector error correction models (VECM) in the Johansen style will be used to model the partial adjustment processes through which the fiscal and stock-flow ratios work, both at an overall level in the 'system VAR' section 6.4 and at an individual sectoral level in section 6.5. Finally, section 6.6 will provide an interpretation of the results and propose some conclusions.

6.1 The Model Structure

The three sector model is a highly aggregated stock-flow model with a single stock — net financial assets — as the measure of wealth. The combined transactions and flow of funds matrix is presented in table 6.1.1 below. At this level of aggregation, the only inter-sectoral flows are government expenditure (G), exports (X), imports (M) and government income, or taxation (T). As it stands, such a limited model does not contain enough information to derive a figure for national income, since two components of aggregate expenditure (consumption and investment) are intra-sectoral flows (internal to the private sector) and do not appear at this level of aggregation. To make progress, private expenditure (PX), which is the combination of private sector consumption and private sector investment, is shown here as a memo item; memo lines are a convention widely used in the stock-flow literature, for example Godley & Lavoie (2007c), where they are used to insert annotations, sub-totals and other items normally limited to a single sector and which cannot therefore be included in the line and column totals. National Income (Y), also shown as a memo item, is the total of $PX + G + X - M$.

	Pvt Sector	Gov't	ROW	Σ
[Memo: Pvt Expenditure]	$[PX]$			$[PX]$
Gov't Expenditure	G	$-G$		0
Exports	X		$-X$	0
Imports	$-M$		M	0
[Memo: National Income]	$[Y]$			$[Y]$
Gov't Income	$-T$	T		0
[Memo: Private Disposable Income]	$[PDY]$			$[PDY]$
Net Lending/Borrowing (NLB)	$G - T + X - M$	$T - G$	$M - X$	0
ΔNet Financial Assets	ΔNFA_p	ΔNFA_g	ΔNFA_f	0
Sectoral Totals	0	0	0	0

Table 6.1.1: The Transactions Matrix and Flow of Funds

All of the components of national expenditure flow through the private sector and are summed to show national income. The column totals give the balance for each sector, which is given the title 'net lending or borrowing' (NLB) as commonly used in national income accounting. The flow of funds account shows the sources and uses of funds by each sector, so shows how the surplus or deficit represented by the NLB is distributed. Here, it has a single line, (ΔNFA) the change in net financial assets, since there is only one stock. The figures for NLB and ΔNFA will have opposite signs (since a positive NLB is a surplus and a negative ΔNFA is a *use* of funds, and vice versa) allowing the sectoral totals to sum to zero. In the case of the private sector, the column total can be derived in two ways, by summing the memo items or summing the non-memo items,

$$\text{Memo Lines: } NLB_p = PDY - PX$$

showing that the private sector balance is the difference between private disposable income and private expenditure, and

$$\text{Non-Memo Lines: } NLB_p = G + X - M - T$$

showing that the private sector balance is just the sum of the other two sectors.

In the balance sheet, the entries for net financial assets of the three sectors are all shown as positive quantities even though at least one of them must be negative if they are to sum to zero as required. Normally, the public sector is a net debtor so the net financial assets of the government would be negative (government debt). The main creditor of the government is normally the private sector which uses government debt as a holding for its wealth; the foreign sector balance may be positive or negative depending on whether this is a surplus or deficit economy in the sense discussed in section 5.2.

	Pvt Sector	Gov't	ROW	Σ
Net Financial Assets	NFA_p	NFA_g	NFA_f	0

Table 6.1.2: The Balance Sheet

6.2 The Populated Model

The matrices of the model in tables 6.1.1 and 6.1.2 can be fully populated with actual data from the US Integrated Macroeconomic Accounts (F.R.B. 2018), and this is shown in tables 6.2.1 and 6.2.2 below. The data are quarterly, covering the period from 1960 to 2016. Each cell in the matrix is therefore a time series, the figures shown in the tables are for the fourth quarter of 2016.

The reference column on the right-hand side of the table contains references to table 3.2.8 for 'atomic' data items (with a prefix A:) and table 3.2.4 for 'composite' data items (with a prefix C:). Lines with more than one data item have references to descriptions at the foot of the table. The transactions flow matrix in table 6.2.1 contains several 'memo' lines. The purpose of these was described in section 6.1 above. In this case, because of the aggregated private sector, private expenditure is a transaction that is internal to the private sector, but without this the model cannot produce a result for national income. The first memo line introduces private expenditure (PX). When this is summed with the other expenditure items, government expenditure (G) and net exports ($X - M$), the result is Net National Income (Y), the second memo line. When taxes and transfers (T) (and statistical adjustments (Note 3)) are deducted, the third memo line for private disposable income is obtained. Private Disposable income less private expenditure gives (after deducting capital transfers (Note 4)) the change in net lending/borrowing (NLB) which is the private sector balance. The same balance is obtained by ignoring the memo lines and summing the

US$billion	Note	Pvt Sector	Gov't	ROW	Σ	Ref
[Memo: Pvt Expenditure]		[13708.4]			[13708.4]	$(C:15)$
Gov't Expenditure		2803.6	-2803.6		0	$(C:1)$
Exports	1	2492.4		-2492.4	0	$(A:5)$
Imports		-2805.8		2805.8	0	$(A:4)$
[Memo: Net National Income]	2	[16312.9]			[16312.9]	$(A:14)$
Taxes and Transfers		-1195.1	1051	144.1	0	Ref[1]
Adjustment 1	3	-713	713		0	$(A:13)$
[Memo: Private Disposable Income]		[14404.8]			[14404.8]	$(A:9)$
Adjustment 2	4	-16.6	16.2	-0.4	0	Ref[2]
Net Lending/Borrowing (NLB)	5	679.9	-1023.5	457.9	114.3	Ref[3]
ΔNet Financial Assets		-679.9	1023.5	-457.9	-114.3	Ref[4]
Sectoral Totals			0	0	0	0

Table 6.2.1: The Transactions Matrix and Flow of Funds - 2016Q4

Source: US IMA

		Private Sector	Public Sector	Foreign Sector
Ref[1]	Taxes and Transfers	$(C:20)$	$(C:24)$	$(C:16)$
Ref[2]	Adjustment 2	$(A:27)$	$(A:28)$	$(A:29)$
Ref[3]	NLB	$(A:31)$	$(A:32)$	$(A:33)$
Ref[4]	ΔNFA	-$(A:31)$	-$(A:32)$	-$(A:33)$

('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)

Note 1 Includes net income from the rest of the world.

Note 2 The total of the expenditure items differs from the figure for Net National Income by 114.3 which is the statistical discrepancy. The statistical discrepancy is the difference between the expenditure and the income methods of calculating GDP (refer table 3.2.8, line 1).

Note 3 This adjustment is required because all income in the matrix in table 6.2.1 is assigned to the private sector whereas in the national income accounts some of that income is due to the government sector. The adjustment ensures that the column total for the Gov't sector matches the public sector Net Lending/Borrowing from the national accounts.

Note 4 This adjustment is for capital transfers which, in the national accounts, are deducted from net savings to arrive at the figure for Net Lending/Borrowing.

Note 5 The residual in the Σ column for Net Lending/Borrowing (and consequently ΔNet Financial Assets) is the statistical discrepancy referred to in Note 2. It arises again here because NLB is the difference between the income and expenditure totals.

inter-sectoral flows, as was shown on page 290.

To complete the empirical model, the balance sheet is shown in table 6.2.2 below. Since this highly aggregated model only has a single stock, namely the net financial assets of each sector, the balance sheet consists of a single line. Note that, the sign convention has been chosen so that the row should total to zero, hence the value of the financial assets of the ROW sector is an asset to the rest of the world and a liability to the United States. In this case, the International Investment Position (IIP) of the US is negative, the rest of the world holds US assets in excess of American-owned assets abroad. The debt of the US government of $USbn 88487.6 is held roughly half by the US private sector, $USbn 47453.1 and the rest by foreigners $USbn 41741.4.

billion $US	Pvt Sector	Gov't	ROW	Σ
Net Financial Assets	47453.1	−88487.6	41741.4	707[1]

Table 6.2.2: The Balance Sheet for the Three Sector Empirical Model (2016Q4 shown)

Source: US IMA
Cumulative NLB(cap) (pvt) (C:27)
Cumulative NLB(cap) (gov) (C:28)
Cumulative NLB(cap) (row) (C:29)
('A:' refers to the line number in table 3.2.8)
[1]Residual Balance due to Statistical Discrepancy

6.3 Ratio Analysis of the US Economy

To prepare for the analysis of the empirical model, the flow ratios for the US economy are presented in figure 6.3.1 and the stock-flow ratios in figure 6.3.2.

Comparing the plot of the flow ratios for the US economy in figure 6.3.1 with the patterns in section 5.6 of the previous chapter, shows that the US has been a deficit economy throughout the sample period but, up until the mid-1960s the

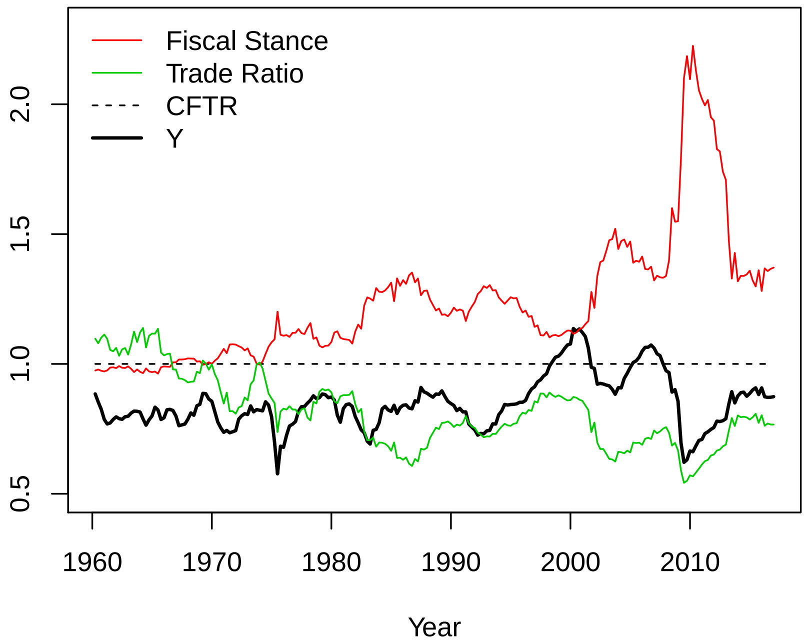

Figure 6.3.1: The US economy: The flow ratios

Source: US IMA
Fiscal Stance (C:4)
Trade Ratio (C:8)
Combined Fiscal and Trade Ratio (C:9)
Gross National Income (C:25)
('C:' refers to the line number in table 3.2.4)

balances were quite small; at that time, foreign trade performance deteriorated, creating matching budget deficits (a twin deficits configuration, p, 35). For most of the period up until the mid 1990s, the private sector surplus was quite steady, being balanced by a rising budget deficit. During the 1990s, the US government was running a very restrictive fiscal policy which reduced the budget deficit but pushed the private sector into deficit, which Godley linked to the imbalances leading up to the dotcom bubble (Godley 1999c). The mid 1980s and especially the period following the dotcom bubble were periods of worsening trade performance and in the post-crisis period the current account remains in deficit while the national income appears to be stabilising at its pre-crisis level.

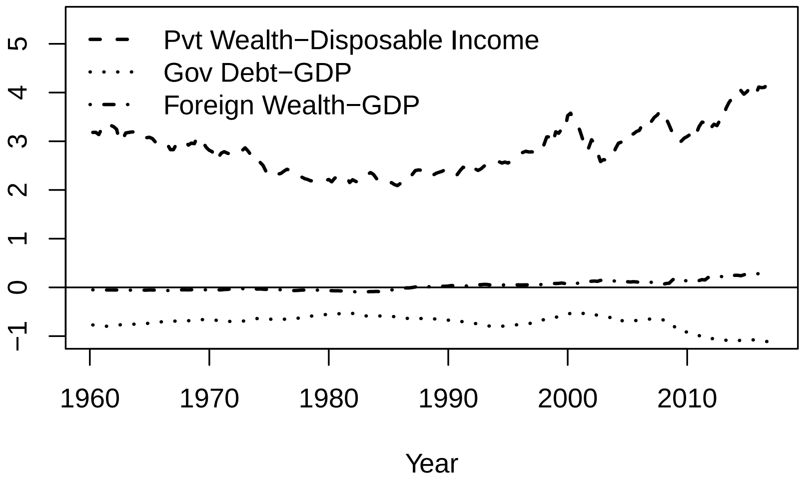

Figure 6.3.2: The US economy: The Stock-flow Ratios
The ratios use the stock values from the balance sheet (table 6.2.2). For the private sector the flow is private disposable income, for the public and foreign sectors the flow is GDP.
Source: US IMA

The stock-flow ratios for each sector are shown in figure 6.3.2. The private sector wealth-income ratio shown here is one of those studied in section 4.2.1.1 (figure 4.2.6). Of the three ratios, it is the most volatile, particularly in the period of the crises. By comparison, the public and foreign sector ratios appear relatively stable. The worsening trade performance discussed above causes the foreign wealth ratio (that is, the claims of foreigners against the US domestic economy) to increase steadily from the 1990s onward, accelerating in the post-crisis period, meaning that the US International Investment Position (IIP) is deteriorating in this period. The rise in the private and foreign wealth ratios is reflected in the government debt-GDP ratio which increases steadily during the crises; the assets being acquired by the private and foreign sectors are the debt securities issued by the government. These historical values will serve as a benchmark in the following sections.

6.4 The System VAR

This section develops the main empirical representation of the three sector SFC model presented above, based on the data series in the populated version of the model in tables 6.2.1 and 6.2.2. The modelling method is based on the Johansen cointegration VAR[1] model and the six-step procedure outlined in section 3.1.2.2 (p.128), reproduced here for reference.

Step 1: Perform any required transformations of the data.

Step 2: Carry out unit root tests on the individual time series to determine their order of integration.

Step 3: Identify any breakpoints in the series.

Step 4: Determine the lag order of each VECM.

[1] The terms VAR and VECM are both used in this section, in fact all of the models are actually VECMs.

Step 5: Estimate the VECM and determine the order of cointegration from the rank of the $\mathbf{\Pi}$ matrix.

Step 6: Determine the long-run cointegrating relationship and compare its form with the expected relationships between the time series.

Two sets of models are developed, the first in this section is a 'system model' capturing all three sectors together. The second set are 'sectoral models' — individual models of each sector in section 6.5 to investigate whether their dynamics is consistent with the partial adjustment processes developed in section 5.2.

6.4.1 The Expenditure Flow VECM

The first of these system VARs models the expenditure flow equation 5.12, (p.252) in which a vector of the main expenditure flows, private expenditure (PX), government expenditure (G) and exports (X) are related to a vector of their lagged corresponding sectoral stocks, private sector net financial assets (FA), government debt (GD) and foreign reserves (FR) by a matrix formed of the parameters of the system — the tax rate (θ), the propensity to import (μ), the stock-flow norms (α, γ, η) and the speed-of-adjustment factors (ϕ, ψ, ξ).

$$\begin{bmatrix} PX \\ G \\ X \end{bmatrix} = \boldsymbol{A} \cdot \begin{bmatrix} FA \\ GD \\ FR \end{bmatrix}_{-1}$$

6.4.1.1 VECM Estimation

6.4.1.1(a) Step One: Transform Data.

Plots of these series in figure 6.4.1 show that they have non-linear trends due to growth and inflation, and are also very volatile particularly in the region of the dotcom bubble and the global financial crisis.

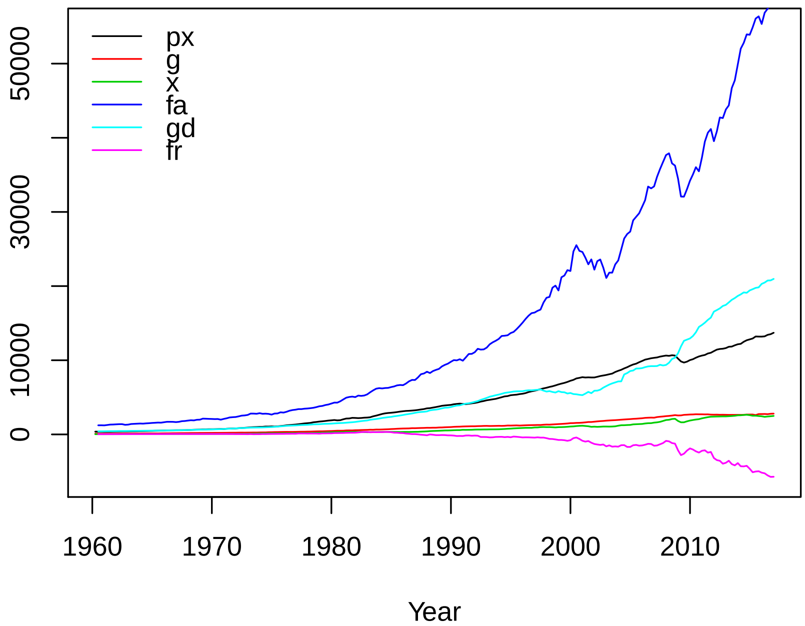

Figure 6.4.1: Plot of the six time series for the System VAR

Source: US IMA
Private Expenditure (C:15)
Total Government Expenditure (C:1)
Exports (A:5)
FA is NLB Stock(pvt) (A:42)
GD is NLB Stock(gov) (A:43)
FR is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)

A suitable transformation to remove the non-linear trend is to take logs, but some of the series contain negative values. However, if the whole structure is displaced upwards to eliminate the negative values then transformed to logs, the resulting series are almost linear and much of the volatility has been removed. In the rest of this section, the transformed variables will be referred to using lower case letters.

6.4.1.1(b) Step Two: Unit Root Tests.

The next step is to perform unit root tests on the transformed time series. Continuing the practice set in chapter 4, both the *Augmented Dickey Fuller* (ADF) and the KPSS (Kwiatkowski *et al.* 1992) unit root tests will be applied as implemented in R package `urca` (Pfaff 2008a). For the ADF tests, the testing cycle outlined in section 3.1.4 has been applied. The null hypothesis for the ADF test is the presence of a unit root whereas the null for the KPSS test is that the series is stationary. In this respect, the two tests complement each other which is important for the reasons outlined in section 3.1.2.1 (p.125). The tests for the six time series for the full time period are summarised in table 6.4.1.

The type column indicates whether the level series, first differences or second differences were tested. In all cases, for the level series, both tests agree that the series are non-stationary, and for the differenced and double differenced series, the ADF test rejects the null of a unit root, however the KPSS test rejects stationarity in the case of the differenced series for px, g and fr. In these cases, the tests are in disagreement, so the outcome is inconclusive; but since the 'weakness' of the ADF test is that it sometimes fails to reject the null, whereas in these cases it has not failed to reject the null, the benefit of the doubt should go to the ADF test and we conclude that the series are I(1) but not I(2).

6.4.1.1(c) Step Three: Breakpoints.

Plots of these series in figure 6.4.1 showed that there are specific points in the time series where discontinuities were evident, for example, in the period

		1960$Q$2 - 2016$Q$4	
Series	Type	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
px	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
g	Level	accept	reject***
	Difference	reject***	reject**
	2nd Difference	reject***	accept
x	Level	accept	reject***
	Difference	reject**	accept
	2nd Difference	reject***	accept
fa	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
gd	Level	reject**	reject***
	Difference	accept	accept
	2nd Difference	reject**	accept
fr	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept

Table 6.4.1: Unit root tests for the Expenditure Flow time series

Source: US IMA
Private Expenditure (C:15)
Total Government Expenditure (C:1)
Exports (A:5)
fa is NLB Stock(pvt) (A:42)
gd is NLB Stock(gov) (A:43)
fr is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Note: All series in logs
Significance Levels: '***' 1%, '**' 5%, '*' 10%

leading up to the dotcom bubble, and in the vicinity of 2007-8 with the effects of the global financial crisis.

It is expected that two sub-periods for the modelling activity will be necessary, one up to the dotcom bubble, the second covering the whole time range without breakpoints, based on the reasoning that most of the time series were evolving 'normally', that is with a steady growth rate punctuated by occasional downturns, up to the period immediately preceding the dotcom bubble, when the previous pattern was replaced by one of extreme volatility. Best results are expected from the first time period, but the decision to continue with the second is motivated by the fact that some of the series appear to resume their previous trajectory in the post-crisis period.

The choice of the exact breakpoint is made by investigating properties of a sample of VECM estimations covering various ranges up to the dotcom bubble period. Since the Johansen procedure assumes that the residuals will be "white noise", one of the important properties is normality of the residuals. Another consideration is that a meaningful interpretation of this model requires an order of cointegration of 3. Finally, the log likelihood value of each model is considered since this statistic is the basis for the estimation of the model parameters. Comparison of these three properties is shown in figure 6.4.2.

The top panel shows the combinations of lags from 2 to 12 and breakpoints between 1990$Q$1 and 2000$Q$4 which result in a model with an order of cointegration of 3. The middle plot shows that the log likelihood of the models is rising slowly at a roughly constant rate across the whole period, favouring selection of later breakpoints. The lower plot shows the kurtosis of one of the model time series. A Jarque-Bera test on the residuals of the model rejects the null

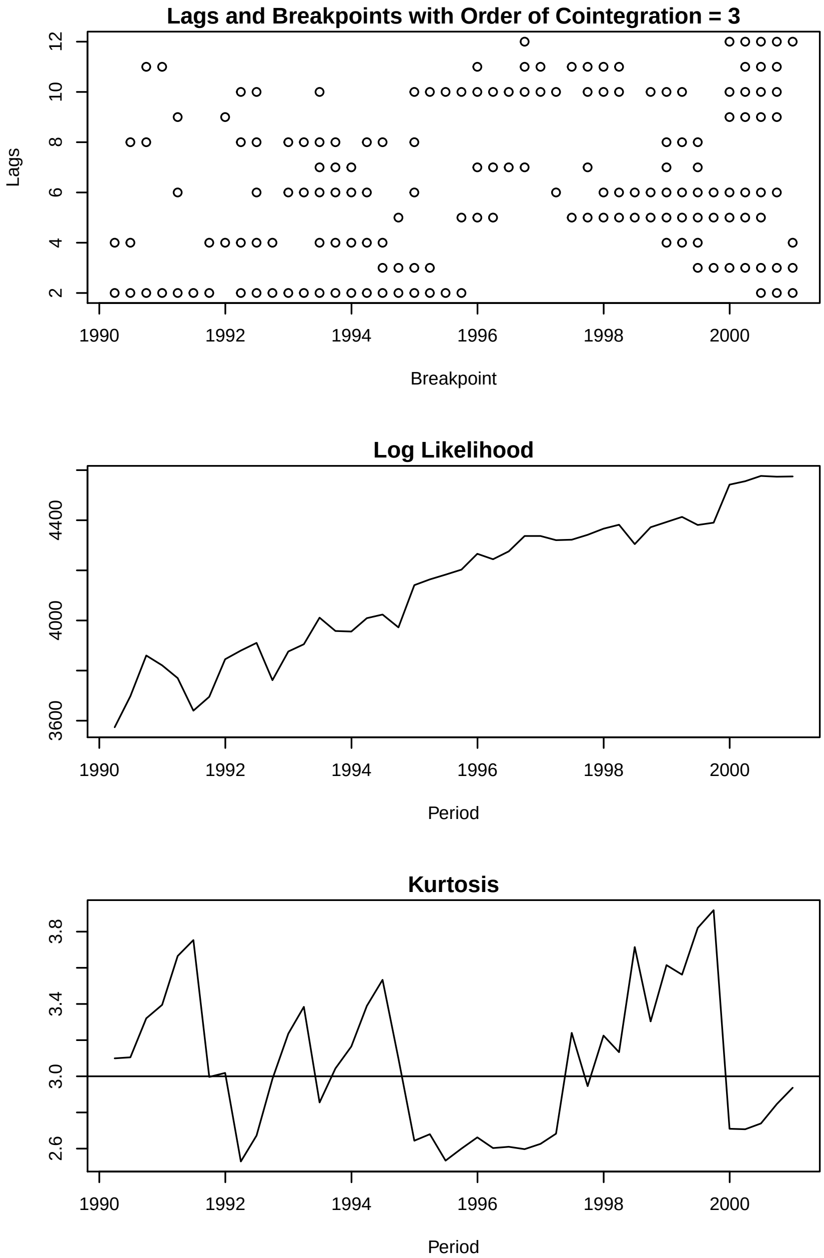

Figure 6.4.2: Choice of Breakpoint: Order of Cointegration, Log Likelihood and Kurtosis

Source: US IMA
Private Expenditure (C:15)
Total Government Expenditure (C:1)
Exports (A:5)
fa is NLB Stock(pvt) (A:42)
gd is NLB Stock(gov) (A:43)
fr is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Note: All series in logs
Significance Levels: '***' 1%, '**' 5%, '*' 10%

hypothesis of normality; skewness for all time series is close to zero, so is not an issue, but they are all 'leptokurtic' which means that the distribution has 'fat tails' caused by the presence of outliers. This plot shows the kurtosis for the time series for government expenditure, which is closest to the 'normal' value of 3, the other time series show similar patterns with slightly higher values. The important point to note is that the level of kurtosis is roughly static across the time range, so does not materially affect the choice of breakpoint. On the basis of this analysis, an initial choice of breakpoint at 1998$Q$1 could be justified by the fact that it is just before the takeoff of the dotcom bubble, and it is consistent with the quality indicators in figure 6.4.2.

6.4.1.1(d) Step Four: Lags.

The other key choice that significantly affects the VECM model is the choice of lags. At the breakpoint chosen in the previous step, the top panel of figure 6.4.2 shows that at least 5 lags are required for the model to show an order of cointegration of 3, but a higher number of lags is also possible, given that increasing the lag order of the model is the usually chosen stratagem for reducing non-normality of the residuals.

Table 6.4.2 shows the reduction in the kurtosis of the residuals of the model for the time period up to the breakpoint by increasing the lags from 5 to 11. A lag length of 10 appears to be close to an optimum, since kurtosis is reduced for all variables compared to 6 lags, and increasing to 11 causes an increase in some cases; so a lag length of 10 will be used for the first period. For the model covering the entire period, a lag length of 11 has been chosen, but even at this level, the kurtosis is much higher than that for the period up to the breakpoint.

	px	g	x	fa	gd	fr
5 Lags	6.29	3.81	4.64	3.73	7.87	9.43
6 lags	6.27	3.59	4.77	3.72	5.86	8.44
10 lags	6.11	3.32	3.17	3.36	4.01	5.54
11 lags	5.48	3.13	2.89	3.51	3.45	7.55

Table 6.4.2: Reduction in Kurtosis with increasing lags series up to the breakpoint

Source: US IMA
Private Expenditure (C:15)
Total Government Expenditure (C:1)
Exports (A:5)
fa is NLB Stock(pvt) (A:42)
gd is NLB Stock(gov) (A:43)
fr is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Note: All series in logs

6.4.1.1(e) Step Five: VECM Estimation.

Having dealt with the issues of lags and breakpoints in the preceding discussions, the estimation of the VECM model can now proceed. The log transformation of the time series appears to have been successful in 'flattening' the deterministic trends and 'taming' the volatility, so that a model covering the whole time period (1960$Q$2 to 2016$Q$4) seems a viable option, but as the Jarque-Bera test results for this period in table 6.4.3 show, the kurtosis in the residuals for this period still raises concerns. Consequently, a second variant of the model covering a sub-period up to the dotcom bubble (1960$Q$2 to 1998$Q$1) will also be estimated. The main device for reducing non-normality of the residuals is to increase the number of lags, and the optimum levels chosen are 11 for the full period and 10 for the sub-period. The 'long run form' of the VECM is estimated with a trend in the cointegrating vector and with four seasonal dummy variables, since the time series are quarterly.

The number of coefficients in the estimated VECMs is large due to the number of lags chosen, so the coefficients and standard errors for both periods are listed in the tables in Appendix B. Many of the coefficients appear to have low individual significance but an F-test that the coefficients of the equations are jointly zero is rejected, see table 6.4.3. The results of further diagnostic tests for autocorrelation, heteroskedasticity and normality of the residuals are also given in table 6.4.3.

	Δpx	Δg	Δx	Δfa	Δgd	Δfr
Significance of Coefficients F-test: Null Hypothesis, Coefficients = 0						
Period 1	reject***	reject***	reject***	reject***	reject***	reject**
Period 2	reject***	reject***	reject***	reject***	reject***	reject***
Normality Jarque-Bera Test: Null Hypothesis, Normally Distributed Residuals						
Period 1	reject***	accept	accept	accept	reject***	reject***
Period 2	reject***	accept	reject***	reject***	reject***	reject***
Autocorrelation Box-Pierce Test: Null Hypothesis, No Autocorrelation						
Period 1	reject*	reject***	reject***	reject*	reject**	reject***
Period 2	reject**	reject*	reject**	reject**	reject***	reject**
Heteroskedasticity ARCH-LM Test: Null Hypothesis, Not Heteroskedastic						
Period 1	reject***	accept	accept	accept	accept	reject*
Period 2	reject***	reject*	reject**	reject***	reject***	reject***

Table 6.4.3: Diagnostic Tests For System VAR

Source: US IMA
Private Expenditure (C:15)
Total Government Expenditure (C:1)
Exports (A:5)
fa is NLB Stock(pvt) (A:42)
gd is NLB Stock(gov) (A:43)
fr is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Note: All series in logs
Significance Levels: '***' 1%, '**' 5%, '*' 10%

As expected, the diagnostics for the pre-dotcom sub-period are more favourable than those for the whole period. The F-test for coefficients jointly insignificant is convincingly rejected in both cases. The Jarque-Bera test shows that normality of residuals has almost been achieved for period 1, but px and fr show values for kurtosis of 4.75 and 5.88 respectively, most likely due to a greater presence of outliers in these series compared to the others. The autocorrelation according to the Box-Pierce test remains high in both periods, despite the high number of lags in the VAR. The ACF for g, which scores worst on this test, shown in figure 6.4.3 indicates that the autocorrelations are not individually significant however they do exhibit a low frequency oscillating sine wave pattern. Oscillations in the ACF arise due to negative values of some of the coefficients of the underlying AR(k) process, however the important point to note is that the pattern is stationary. The results for the test of heteroskedasticity are acceptable for the first period with the sole exception of px, and even for the full period, the heteroskedasticity is still not too much out of limits. It's paradoxical that the heteroskedasticity for px should be highly significant in the first period but not in the second.

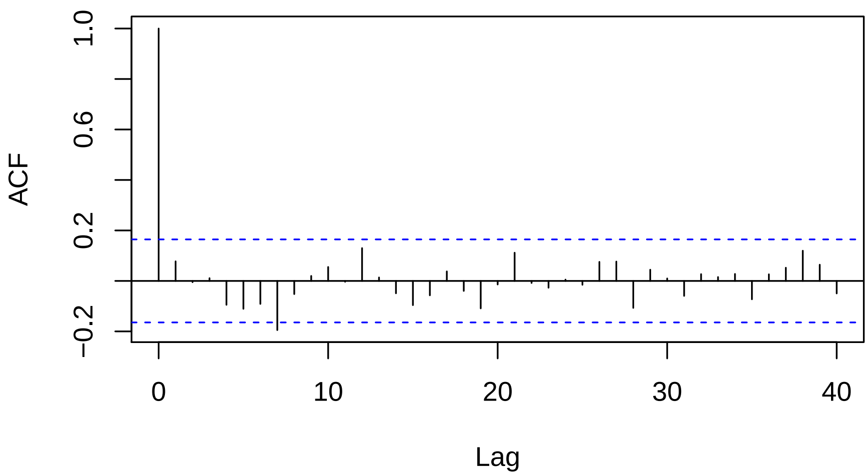

Figure 6.4.3: Autocorrelation Function for residuals of g in first period

The purpose of investigating these diagnostic tests is to have some reassurance that the VAR model is econometrically sound, however the outcome is not critical in this case, since we are not intending to perform any statistical inference on the results of the model.

6.4.1.1(f) Step Six: The Long-run Cointegration Relationship.

The final step, and the purpose of the whole exercise, is to extract the cointegrating relations between the time series resulting from the VECM estimation. The cointegrating vectors are in the β matrix and when applied to the lagged time series yields the set of cointegrating relations — stationary time series formed from a linear combination of the constituent non-stationary time series of the model. In this case, there are three cointegrating relations, for the first time period 1960$Q$2 to 1998$Q$1,

$$\text{CR1: } px - 3.98fa + 5.68gd + 3.55fr$$
$$\text{CR2: } g - 2.71fa + 4.31gd + 2.87fr$$
$$\text{CR3: } x + 1.6fa - 2.93gd - 1.56fr$$

and for the complete period, 1960$Q$2 to 2016$Q$4,

$$\text{CR1: } px - 0.32fa - 0.37gd + 0.11fr$$
$$\text{CR2: } g - 0.05fa - 0.42gd - 0.22fr$$
$$\text{CR3: } x + 0.46fa - 1.99gd - 0.79fr$$

The cointegrating relations are plotted for the two periods in figure 6.4.4, the top panel showing period 1, the lower panel showing the full period. The relations for both periods give the appearance of being stationary — this impression is reinforced by the co-plotting.

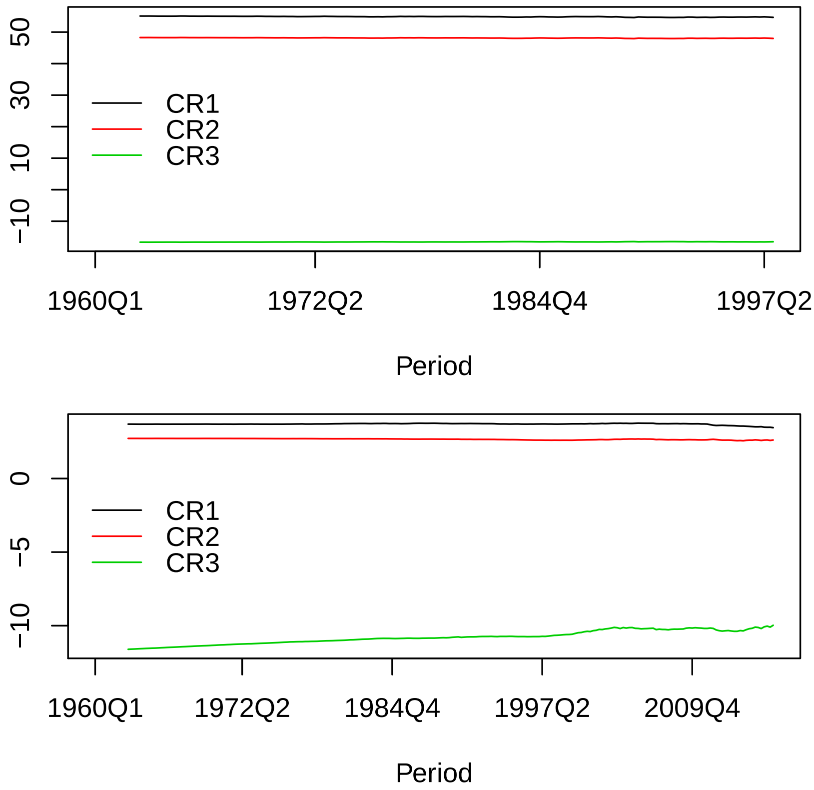

Figure 6.4.4: Cointegrating Relations for System VAR
Top Panel: Period 1 1960$Q$2 to 1998$Q$1
Lower Panel: Period 2 1960$Q$2 to 2016$Q$4

In the cointegration model, these relations represent long-term 'equilibrium' relationships between the variables of the model. It's noticeable that the relations change significantly between the two periods, for example, CR1 is a relationship between px, fa, gd and fr which, in the first period is roughly stationary around a mean of approximately -1.25; but for the full period, CR1 has a mean of 4.86; and the changes for CR2 and CR3 are even larger. Considering that these variables are log quantities, that is a big change. A related difference is that the coefficients of the variables change significantly between the two periods, CR1 is the most stable where the coefficients of fa and gd are comparable between the two, but fr changes sign. For CR2 and CR3, the coefficients are not comparable between the two periods. even though the second period takes in the instability of the financial crises, this degree of discontinuity is surprising.

One could conclude that the log transformation in step one was successful in stabilising the time series so that stable cointegrating relations were found, but makes interpretation of the results more difficult. The cointegrating relations are additive relations between the logs of the variables, meaning that the relationship between the original variables is multiplicative. This makes it difficult to interpret the partial adjustment processes in this result. Furthermore, comparing the coefficient matrix from the cointegrating relations with that of equation 5.12 will yield little insight into the values of the partial adjustment parameters; section 6.5 will construct VECMs of each sector individually which will ease the task of interpretation where there are fewer variables.

6.4.2 The Financial Assets Stock VAR

The first of the system VARs in the previous section modelled the expenditure flow equation 5.12 (p.252) in which the main expenditure flows are related to their corresponding sectoral stocks. This section deals with equation 5.14 (p.253); whereas equation 5.12 is a stock-flow equation, relating flows to opening period stocks, equation 5.14 incorporates the second part of the cycle, how flows update stocks, and hence is a stock-stock equation.

$$\begin{bmatrix} FA \\ GD \\ FR \end{bmatrix} = \boldsymbol{B} \cdot \begin{bmatrix} FA \\ GD \\ FR \end{bmatrix}_{-1}$$

This is a homogeneous linear difference equation, and it was observed in section 5.3 that consequently, there was no long-term steady-state solution, the equation gives solutions only for the transient movements in the stocks. This poses an interesting issue for VECM modelling since its purpose is to identify cointegrating relations between the time series which are interpreted to be long-run steady-state relations. In this case, the relationship between the stocks is already known — they sum to zero, since these are the net financial assets of the three sectors of the model. Together they consitute the balance sheet of the three sector economy and must sum to zero for accounting consistency. So, in the vector ECM equation, the term $\boldsymbol{\beta' y_{t-p}}$ is zero and the equation reduces to a VAR in differences which just models the short-term fluctuations in the stocks in the same way that the homogenoeous linear difference equation 5.14

just models transients.

$$\boldsymbol{\Delta y_t = \Delta y_{t-1} + \ldots + \Delta y_{t-p+1} + \mu + \Phi D_t + \epsilon_t}$$

The VECM model has not been estimated here since a VAR in differences will not help in establishing the existence of partial adjustment processes in the model.

6.4.3 Summary and Conclusions on the System VAR Models

The purpose of this section was to model the empirical relationships between the flows and the stocks of the entire three sector model viewed as a single system. Chapter 5 introduced a view of economic dynamics based on the interaction of the flow ratios and stock-flow norms expressed as partial adjustment processes; the flow ratios set the target level for the steady state and the partial adjustment processes, which incorporate the stock-flow norms, drive national income to converge towards that steady state. The simulations of section 5.5 demonstrated this relationship computationally, this section aimed to replicate that in an empirical model.

The Expenditure Flow model developed in section 6.4.1 established the existence of cointegrating relationships between the log transformed flows and the stocks. The fact that three cointegrating relations were found, each of which could be expressed in terms of one of the flows and the three stocks, supports the assumption of long-run stable stock-flow relationships of the type described in chapter 5; however, the instability of the underlying time series was still present in the large discontinuities in the cointegrating relations between the first and the second time periods. Furthermore, interpretation of the coefficient matrix from the cointegrating relations in terms of the linear difference equations was not evident, and this is more likely to succeed in the sectoral models of the next section.

The Financial Assets Stock VAR was not estimated because the long-run relationship between the stocks is zero, meaning that the VECM reduces to a VAR in differences. This is a model of the short run impacts, which is consistent with the homogeneous linear difference equation developed in section 5.3.

Finally, it could be said that the VECM estimation of the entire system has been a partial success in the respect that stable cointegrating relations were found in the expenditure flow VECM, but has not risen to the expectation of providing a robust data model in which the hypothesis of partial adjustment processes could be interpreted. That will be pursued further in the next sections.

6.5 The Sectoral Models

Section 5.2 proposed the existence of partial adjustment processes, encapsulating stock-flow norms as the stabilising mechanisms in this three sector economy. There being one stock per sector entailed one partial adjustment process per sector. This section will construct VAR models of each of the three sectors separately to explore these partial adjustment processes empirically.

Each one combines the stock-flow dynamic:

stocks determine current flows... FA_{t-1} is a determinant of PX_t

...flows update stocks $YD_t - PX_t$ becomes ΔFA_t

iterate

with a partial adjustment process,

$$\Delta FA_t = \phi(FA^* - FA_{-1}) \qquad \text{where } \phi \text{ is the } \textit{speed of adjustment} \text{ factor}$$

based on stock-flow norms,

$$FA^* = \alpha YD \qquad \text{where } \alpha \text{ is the private sector } \textit{wealth-income norm}$$

In the case of the private sector, combining these three elements results in the following expression for private expenditure,

$$PX = (1 - \phi\alpha)YD + \phi FA_{-1}$$

which is equation 5.4 derived on page 240 in the course of the discussion on the convergence process. The purpose of the VAR analysis will be to construct an empirical model with these three variables, PX, YD and FA, and to see if there is evidence of this partial adjustment dynamic. Subsequent sections will apply the same procedure in the public and foreign sectors.

6.5.1 The Private Sector Model

Section 3.1.2.2 set out the methodological approach to cointegration VAR analysis used in this empirical work, already demonstrated earlier in the analysis of the system VAR in section 6.4. The sectoral models follow a similar pattern except that, since the hypothesis is that there is a single partial adjustment process for each sector, there will be a single cointegration relation in each VAR. Equation 3.5 (p.136) is the general form of the long-run form of a VECM, which is adapted here to the private expenditure function for the private sector,

$$\Delta \begin{bmatrix} PX \\ YD \\ FA_{-1} \end{bmatrix}_t = \Delta \begin{bmatrix} PX \\ YD \\ FA_{-1} \end{bmatrix}_{t-1} + \ldots + \Delta \begin{bmatrix} PX \\ YD \\ FA_{-1} \end{bmatrix}_{t-p+1} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \cdot [\beta_1, \beta_2, \beta_3] \begin{bmatrix} PX \\ YD \\ FA_{-1} \end{bmatrix}_{t-p} + \boldsymbol{\mu} + \boldsymbol{\Phi D_t} + \boldsymbol{\epsilon_t}$$

where the components are the time series PX, YD from table 6.2.1 and private sector net financial assets (FA_p) from table 6.2.2; $\boldsymbol{\mu}$ is a vector of constants, $\boldsymbol{D_t}$ is a vector of deterministic components and $\boldsymbol{\epsilon_t}$ is a vector of 'white noise' processes. It is written under the assumption that there will be a single cointegrating relationship since $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are shown as $K \times 1$ vectors. The cointegrating relation is captured in the matrix,

$$[\beta_1, \beta_2, \beta_3] \begin{bmatrix} PX \\ YD \\ FA_{-1} \end{bmatrix}_{t-p}$$

6.5.1.1 The Private Sector Model: Estimation

The expectation, if the hypothesis of the presence of a partial adjustment process is supported, is that a single cointegrating relation between the private sector variables will emerge from the VECM estimation. The same six-step procedure set out on page 138 will be followed here.

6.5.1.1(a) Step One: Data Transformation.

For this model, with only three time series, it has not been found advantageous to use the log transformation employed in the earlier system VAR. While the benefits in de-trending and volatility calming are substantial, there are also costs associated with the inverse transformation, i.e. recovering the original time series. The VECM, being a model in differences, gives satisfactory results in this case without the log transformation.

6.5.1.1(b) Step Two: Unit Root Tests.

Unit root tests were performed on PX and FA in the previous section where both series were found to be I(1) but not I(2). The results are reproduced in table 6.5.1, with the addition of YD which reveals it also to be I(1) but not I(2).

		1960$Q$2 - 1997$Q$2	
Series	Type	ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
PX	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
YD	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
FA	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept

Table 6.5.1: Unit root tests for time series in the Private Sector Sectoral Model

Source: US IMA
Private Expenditure (C:15)
Private Disposable Income (A:9)
NLB Stock(pvt) (A:42)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

6.5.1.1(c) Step Three: Breakpoints.

The sectoral models suffer from the same issue of data volatility as the system VARs above, so again, the overall time span will be split into two sub-periods. It happens that the resulting VECM is extremely sensitive to the choice of lags and breakpoints, an issue that will be explored further in section 6.5.1.3 on sensitivity analysis, where the rationale for selecting the breakpoint, 1997$Q$2, will be explained. The period up to the start of the dotcom bubble (1960$Q$2 - 1997$Q$2) is treated as the first period since the variables of the private sector displayed relatively uniform growth in this period; the second interval is the complete period, 1960$Q$2 - 2016$Q$4, which combines the steady growth of the first period with the extreme volatility of the crisis periods. Due to data limitations, no separate models are formed covering the 'trans-crisis' periods.

6.5.1.1(d) Step Four: Lags.

The selection of the lag order of the VECM is combined with the breakpoint selection, to be discussed in section 6.5.1.3. For the time period prior to the dotcom bubble (1960$Q$2 - 1997$Q$2), the number of lags selected is 5, and for the entire period 1960$Q$2 - 2016$Q$4 it is 2.

6.5.1.1(e) Step Five: VECM Estimation.

The 'long run form' of the VECM is estimated with a trend in the cointegrating vector and with four seasonal dummy variables, since the time series are quarterly. For the determination of the order of cointegration, the results according to tests on the maximal eigenvalue and the trace statistics fail to reject the hypothesis of one cointegrating vector at the 1% significance level. The time trend is introduced into the cointegrating relation since the time series are nominal values, not deflated, and naturally have a significant trend.

Including a trend term in the cointegrating relation, separates the effect of the time trend (which captures inflation and growth) from the stochastic relations between the variables.

As with the earlier system VAR, the coefficients and standard errors for both periods are listed in tables C.1 and C.1 in Appendix C. Many of the coefficients appear to have low individual significance but an F-test that the coefficients of the equations are jointly zero is rejected, see table 6.5.2. The results of further diagnostic tests for autocorrelation, heteroskedasticity and normality of the residuals are also given in table 6.5.2.

	ΔPX	ΔYD	ΔFA
Significance of Coefficients			
F-test: Null Hypothesis, Coefficients = 0			
Period 1	reject***	reject***	reject***
Period 2	reject***	reject***	reject***
Normality			
Jarque-Bera Test: Null Hypothesis, Normally Distributed Residuals			
Period 1	reject***	reject***	reject***
Period 2	reject***	reject***	reject***
Autocorrelation			
Box-Pierce Test: Null Hypothesis, No Autocorrelation			
Period 1	reject**	accept	reject*
Period 2	reject***	reject***	accept
Heteroskedasticity			
ARCH-LM Test: Null Hypothesis, Not Heteroskedastic			
Period 1	accept	accept	accept
Period 2	accept	reject***	reject***

Table 6.5.2: Diagnostic Tests For Private Sector VECM

Source: US IMA
Private Expenditure (C:15)
Private Disposable Income (A:9)
FA is NLB Stock(pvt) (A:42)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

As with the system VAR, the diagnostics for the pre-dotcom sub-period are slightly more favourable than those for the whole period. The F-test for coefficients jointly insignificant is convincingly rejected in both periods The Jarque-Bera test rejects the null of normality of residuals in all series, due to the elevated readings for kurtosis, most likely due to the presence of outliers in these series. The autocorrelation according to the Box-Pierce test is acceptable for the first period except for PX which is rejected at the 5% level. The ACF for PX is shown in figure 6.5.1 and indicates that the autocorrelations are not individually significant, except that at lag 8, however they do exhibit the same low frequency oscillating sine wave pattern as for the system VAR. As remarked there, oscillations in the ACF arise due to negative values of some of the coefficients of the underlying AR(k) process, however the important point to note is that the pattern is stationary. The results for the test of heteroskedasticity are acceptable for the first period with the sole exception of FA, and even for the full period, the heteroskedasticity is still not too much out of limits.

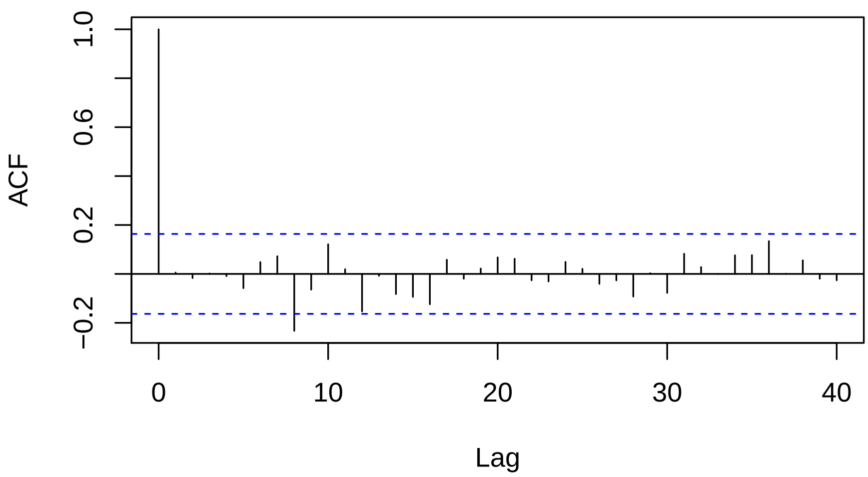

Figure 6.5.1: Private Sector Autocorrelation Function for FA in first period

The purpose of investigating these diagnostic tests is to have some reassurance that the VAR model is econometrically sound, however the outcome is not critical in this case, since we are not intending to carry out statistical inference on the results of the model.

6.5.1.1(f) Step Six: Extract the Cointegrating Relation.

The resulting cointegrating relations are, for the time interval 1960$Q$2:1997$Q$2,

$$\text{CR1: } PX - 0.79YD - 0.03FA + 2.25t$$

and for the complete period, 1960$Q$2:2016$Q$4,

$$\text{CR2: } PX + 0.14YD - 0.15FA + 24.73t$$

In contrast to the results of the system VAR, these relations are comparable between the two periods; in the second period spanning the crises, the coefficients of the variables decrease slightly, but the time trend increases enormously. These differences between the relations for the two periods are made visible by plotting them. Figure 6.5.2 shows a co-plot of the cointegrating relations for both periods. The solid line shows the whole period and illustrates the difficulty of trying to find a single stationary relation when the 'trans-crisis' period is included. The dotted line covers the period prior to the dotcom bubble, and has more the appearance of a stationary time series.

From these values, estimates of the parameters ϕ and α in the partial adjustment

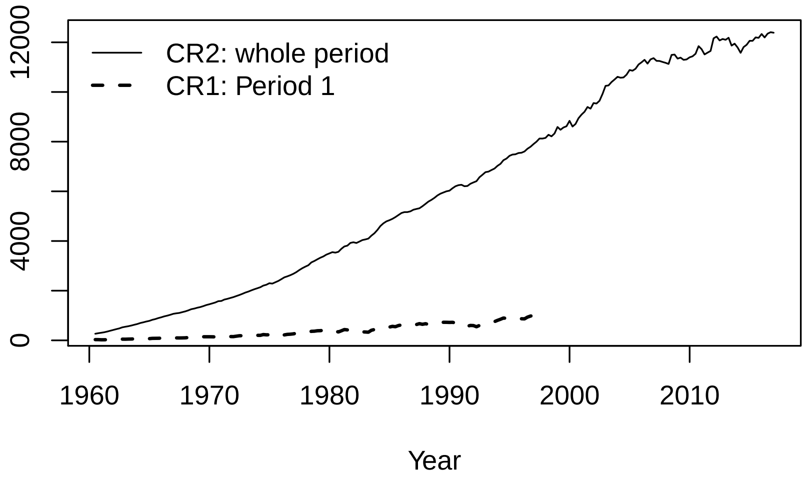

Figure 6.5.2: Cointegrating relations for the private sector VAR

Source: US IMA
Private Expenditure (C:15)
Private Disposable Income (A:9)
FA is NLB Stock(pvt) (A:42)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)

process can be made.

$$1960Q2 : 1997Q2 \qquad \phi = 0.03 \qquad \alpha = 7$$

$$1960Q2 : 2016Q4 \qquad \phi = 0.15 \qquad \alpha = 7.6$$

The values of ϕ for the speed of adjustment factor of the partial adjustment process seem reasonable, in the vicinity of 0.1, so roughly a tenth of the disequilibrium will be 'corrected' in each period. This suggests much 'inertia' in the dynamics.

The value of α for the private sector wealth-income norm in the first period up to the dotcom bubble is broadly in line with the values charted in chapter 4. The actual measure used for the FA time series was the accumulated NLB taken directly from the US IMA balance sheet (see table 3.2.8 line 42 for the exact source). This time series was plotted in figure 4.2.6 and a value of $\alpha = 7$ is quite consistent with the values found there. The value for alpha for the complete period is higher than expected, and can possibly be discounted in favour of the period 1 value due to the volatility of the trans-crisis period.

6.5.1.2 Comparison with the New Cambridge Equation

Section 5.2.1 compared alternative forms of the New Cambridge equation, in particular, its application at different levels of aggregation. This section takes the comparison further by looking at the parameter values estimated for the two forms.

The form of the original equation was shown in section 5.2.1, econometric estimation of this relationship resulted in the following equation (Cripps *et al.* 1976, p.46),

$$PX = 0.533YD + 0.416YD_{-1} + 0.899HP + 0.790BA + 0.962S \tag{6.1}$$

It was remarked earlier that the coefficients of YD and YD_{-1} sum approximately to 1, which was interpreted to mean that virtually the whole of private disposable income will be spent on goods and services with a short lag (one year), supporting the empirical observation that the UK private sector had, over recent decades, consistently run a small and stable balance, an empirical finding that Fetherston & Godley (1978, p.34) called *the explicit hypothesis associated with New Cambridge*.

The equation that has been estimated in section 6.5.1.1 above is in the form of a VECM; this produces the cointegrating relation which is an estimate of the long-run equilibrium relationship between the variables. For the time interval $1960Q2{:}1997Q2$, the estimated stable relationhip was

$$\text{CR1: } PX - 0.79YD - 0.03FA + 2.25t$$

This is an expression for a time series, not an equation. However, it is a stationary series so ΔCR1: should be approximately zero, leading to the following equation,

$$\Delta PX = 0.79\Delta YD + 0.03\Delta FA - 2.25$$

This implies that, in the log-run, two thirds of any increase in disposable income and ten percent of changes in wealth will go into changes in private expenditure. To compare with 6.1, it is necessary to recall the discussion from section 5.2.1 about levels of aggregation; the New Cambridge equation operates at the level of the households and firms sector and includes net lending but has no wealth term; CR1 operates at the level of the whole private sector, so net lending is not 'visible' but it does contain a wealth term. Bearing in mind these differences, a parameter value of two thirds for disposable income is 'in between' the current and lagged values in 6.1 and could be interpreted as a long-run average after changes in net lending have worked through into asset values.

Another estimation of the New Cambridge equation was published in Zezza (2009). It is a difference equation in ΔPX which forms part of the Levy Institute SFC model of the US economy.

$$\Delta PX_t = -0.34PX_{t-1} + 0.27YD_{t-1} + 0.04FA_{t-1} + 3.08PFA_{t-1} + 3.08PH_{t-1} + 0.20DBH_{t-1}$$

$$+0.11DBB_{t-1} + 0.20\Delta PX_{t-1} + 0.42\Delta YD + 0.17\Delta DBH + 0.08\Delta DBB - 186.24$$

where,

PE is private expenditure at chained 2000 prices;

YD is private disposable income at chained 2000 prices;

FA is the opening stock of financial assets, deflated by the PE deflator. The stock of financial assets is the sum of government debt (obtained by cumulating government deficits from a benchmark value) and foreign net assets (obtained by cumulating the current account balance from a benchmark value);

PFA is S&P 500 index, deflated by the PE deflator;

PH is the Realtor.org index for the median price of existing single-family homes, deflated by the PE deflator;

DBH is the change in household debt outstanding, deflated by the PE deflator;

DBB is the change in business debt outstanding, deflated by the PE deflator.

This equation also acts at the level of the households and firms sector so, in that respect, is comparable with the original New Cambridge equation, having terms in disposable income and net lending, but it adds terms for price levels (the S&P 500 and house prices), a stock term and Δ terms in income and net lending; it is also autoregressive, having lagged terms in PX and ΔPX. This makes direct comparison with CR1 and with 6.1 hazardous, but it's worth noting the large contribution to changes in private expenditure coming from the two price indices, the stock market and the housing market[2]; and the relatively smaller contribution of income, financial assets and net lending. The previous period's expenditure has a negative impact on changes in current expenditure, but all other coefficients are positive, suggesting a 'pro-cyclical' dynamic from the other regressors.

[2]The study was published in 2009 just after the peak of the housing bubble with the dotcom bubble still in recent memory.

Martin (2012) provides a more recent study of the New Cambridge model and arrives at the following result (Eqn (16), p. 100),

$$E^S = 0.87Y^a + 1.41(V + 689.2(100k) - 417,263)$$

where E^S is expenditure in the long-run static-state, Y^a is income adjusted for the 'inflation tax', V is financial weath and k is the ratio of non-financial wealth to income.

This is also a 'disaggregated' model since it operates on the 'market sector' which is a term he uses for households and non-financial firms. However, it doesn't have a term in the flow of net lending but, like the Levy model above, does consider the wealth effects of non-financial assets through the ratio of non-financial wealth to income.

A direct comparison is made difficult by the different definitions of the terms in the equation. In a comparison between the original New Cambridge equation and his more recent study, Martin (2012) identifies three main points. Firstly, the steady state properties; under New Cambridge, the ratio of the private financial surplus to income tends to a constant and this is also implied by the new study. Secondly, the speed of adjustment; New Cambridge proposed the *mean lag theorem* in which the mean lag of the response of private expenditure to a change in private disposable income is equal to α, the financial wealth-income norm. It was acknowledged that this theorem loses its power if the expenditure-income response is oscillatory. The new study finds the response to be oscillatory. Thirdly, concerning the causes of the historic increase in the variability of the private sector financial surplus, in other words, why has the private sector balance been so volatile, even during the relative stability of 'the great moderation'? The original New Cambridge explanation is in terms of inflation but, the new study finds that just allowing for the 'inflation tax' does not explain it, offering instead a new explanation in the role played by asset prices.

In conclusion, these two published studies have modified the original New Cambridge hypothesis in different ways; the "explicit hypothesis associated with New Cambridge" (Fetherston & Godley 1978, p.34) was that, over time, the private sector runs a small and stable balance. The underlying idea was that these small, stable balances accumulated into stocks of financial assets that acted as a regulator on expenditure and saving, similarly to the action of an integral control system (Phillips 1954) (discussed in section 2.2.1.4). However, that empirical observation did not survive into the neoliberal era with its financialisation and asset price inflation. Martin (2012) finds an explanation for the volatility of the private sector balance in the role of asset prices; Zezza (2009) explicitly introduces price indices for the stock market and the housing market into the equation.

Having accounted for asset prices, both models still find the aggregated private expenditure function a good functional form for the model, and the principal determinants of private expenditure to be disposable income, accumulated financial assets and, in the case of the Levy model, in the flow of net lending to the private sector. In this way, both are true to the original New Cambridge idea, even if in a modified form.

But the cointegrating relation CR1 from the VECM model in section 6.5.1.1 is not directly comparable, operating as it does at a different level of aggregation;

it works on that underlying dynamic where the interaction between private sector surpluses and accumulating asset values form a stable relationship; and those elements are still to be found in the two disaggregated models, although with a different emphasis, as such it provides a long-term view at a highly aggregated level.

6.5.1.3 Private Sector Model: Sensitivity Analysis

The VECM estimation results have proved to be very sensitive to choice of lags and breakpoints. Since the objective has been to determine whether a simple partial adjustment process based on stock-flow norms could be a plausible explanation for the dynamics of this three sector model, the selection of lags and breakpoints was guided by this objective, but there were combinations which showed features incompatible with this explanation, for example lack of cointegration, 'wrong' signs of parameters etc. To investigate the variation in the results caused by selection of lags and breakpoints, the lags were varied from 2 up to 6 and the date for the first breakpoint was allowed to range over the interval 1996Q1 to 2000Q4; for each combination, a VECM estimation was made and the resulting parameters compared. The parameters of interest are the order of cointegration which specifies how many cointegrating relationships exist in the data, and the elements β_2 and β_3 of the cointegrating vector which become the coefficients of YD and FA in the cointegrating relation. These, in turn, determine the values of ϕ, the speed of adjustment factor, and α, the wealth-income norm, in the partial adjustment process.

The range of potential dates for the breakpoint and the range of lags gave 120 possible combinations. In nearly all cases, the order of cointegration was one.

Column 2 of table 6.5.3 shows the results for two cases, with and without a trend in the cointegrating relationship.

The β_2 component of the cointegrating vector becomes the coefficient of the YD term in the cointegrating relation, and consequently, determines the value of α, the wealth-income norm. To conform with the hypothesis of a partial adjustment process, values of β_2 should be greater than -1. Of the cases where the order of cointegration was one, the number showing β_2 in the required range was 109 with no trend in the cointegrating relation but dropped to 70 when the trend was selected.

The third element of the β vector determines the speed of adjustment factor in the partial adjustment process. It also becomes the coefficient of the FA term in the relation for private expenditure and determines the degree to which financial assets are 'converted to' private expenditure. To conform with the hypothesis of a partial adjustment process, β_3 should be in the interval $-1 < \beta_3 < 0$ with values clustered just below zero. With the 'no trend' option, there were 78 within the required range, a total that dropped to 30 with the selection of a trend in the cointegrating relation. A value of β_3 greater than zero would result in a negative wealth term in the private expenditure relation which might be interpreted to mean that increasing levels of financial assets reduce private expenditure. This could be a plausible scenario in the deleveraging period following the collapse of the dotcom bubble.

Having considered the acceptable values of β_2 and β_3 separately, a further consideration is whether they combine to produce meaningful values of α, the wealth-income norm, i.e. positive values. With no trend in the cointegrating relation, the number of combinations producing a meaningful α was 85 and 78 when the trend was selected. Interestingly, the number of cases with a positive α were greater than the number with positive ϕ, meaning that there were 7 of the cases without trend and 42 of the cases with trend where the value of ϕ was negative, implying that private expenditure and financial wealth were negatively correlated in these models.

Trend Type	Cointegration Order =1	β_2 $-1 < \beta_2$	β_3 $-1 < \beta_3 < 0$	α $\alpha > 0$
No Trend	115/120	109/115	78/115	85/115
With Trend	111/120	70/111	30/111	72/111

Table 6.5.3: Sensitivity of Parameters to selection of Lags and Breakpoints in the First Period
For breakpoints in the interval 1995Q1 - 2000Q4 and lags between 2 and 6, total combinations of 120

It's difficult to understand why the inclusion of a trend in the cointegrating relationship should affect the partial adjustment parameters in this way. The combinations with positive values of ϕ and α in the 'with trend' estimations was just 25% which strains the credibility of the partial adjustment process explanation. It seems that the removal of the time trend changes the characteristics of the relationships between the other variables. On the other hand, the proportion of cases in the 'no trend' estimations that display acceptable values of the partial adjustment parameters is reasonably high, $\approx 70\%$ which lends significant support to the proposition that partial adjustment processes encapsulating stock-flow norms are active in the dynamics of the private sector.

6.5.1.4 Summary and Conclusions on the Private Sector Model

The purpose of this section has been to model the private sector of the three sector model of the US economy under the assumption that its dyamics are driven by a partial adjustment process incorporating a wealth-income norm.

A VECM model with the two private sector flows, PX and YD, and the private sector financial stock, FA, found a single cointegrating relation between the time series for most, though not all combinations of lags and breakpoints in the period preceding the dotcom bubble with slightly fewer in the second period which included the crises. From the cointegrating vectors of the model estimations it is possible to extract the implied form of the equation for the partial adjustment process (eqn 5.4, p.240),

$$PX = (1 - \phi\alpha)YD + \phi FA_{-1}$$

and hence to derive estimates of the speed-of-adjustment parameter, ϕ, and the wealth-income norm, α. The proportion of cases yielding meaningful estimates of these parameters was rather low as table 6.5.3 showed, of the order of 2/3 with no trend cointegration relation and down to 1/4 for the case with trend on a sample of time series with start point 1960Q2 and end points in the range 1995Q1 to 2000Q4 and with lags between 2 and 6.

This is not a ringing endorsement of the partial adjustment dynamic, neither is it a refutation of the principle. That the time series are cointegrated is to be expected since they are related by an accounting identity, $YD - PX = \Delta FA$, but the cointegrating parameters only partially support the dynamic equation above. Possibly there are more complex dynamics at work, complementary or perhaps contending with this one which have not been able to be identified at this stage of the research.

6.5.2 The Public Sector

This section is a virtually a rerun of the procedure in section 6.5.1 above, this time applied to the public sector. The same steps will be followed, although now that the pattern is established, some of the detail will be skipped. The objective is the same, to examine the evidence for a partial adjustment process in the public sector. The public expenditure equation was developed in the form of a partial adjustment process in section 5.2 resulting in equation 5.5 (p.241),

$$G = (\theta + \psi\gamma)Y - \psi GD_{-1}$$

This is transformed into the long-run form of a VECM, following the general pattern for the VECM in equation 3.5 (p.136),

$$\Delta \begin{bmatrix} G \\ Y \\ GD_{-1} \end{bmatrix}_t = \Delta \begin{bmatrix} G \\ Y \\ GD_{-1} \end{bmatrix}_{t-1} + \ldots + \Delta \begin{bmatrix} G \\ Y \\ GD_{-1} \end{bmatrix}_{t-p+1} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \cdot [\beta_1, \beta_2, \beta_3] \begin{bmatrix} G \\ Y \\ GD_{-1} \end{bmatrix}_{t-p} + \boldsymbol{\mu} + \boldsymbol{\Phi D_t} + \boldsymbol{\epsilon_t}$$

where the components are the time series G, Y from table 6.2.1 and public sector debt (GD) from table 6.2.2; $\boldsymbol{\mu}$ is a vector of constants, $\boldsymbol{D_t}$ is a vector of deterministic components and $\boldsymbol{\epsilon_t}$ is a vector of 'white noise' processes. It is written under the assumption that there will be a single cointegrating relationship since $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are shown as 3×1 vectors. The cointegrating relation is captured in the matrix,

$$[\beta_1, \beta_2, \beta_3] \begin{bmatrix} G \\ Y \\ GD_{-1} \end{bmatrix}_{t-p}$$

6.5.2.1 The Public Sector Model: Estimation

The expectation, if the hypothesis of the presence of a partial adjustment process is supported, is that a single cointegrating relation between the public sector variables will emerge from the VECM estimation. The same six-step procedure set out previously will be followed here, though in a slightly abridged form.

6.5.2.1(a) Step One: Data Transformation.

As for the private sector, the log transformation has not been used, the public sector VECM gives satisfactory results in this case without the log transformation.

6.5.2.1(b) Step Two: Unit Root Tests.

Table 6.5.4 presents the results of unit root tests on the public sector variables. There is just one point of contention where the ADF test rejects the null hypothesis of a unit root for the differenced series for government debt, GD, while the KPSS test rejects the null hypothesis of stationarity, though only at the 10% level. Nevertheless, it will be assumed that all are I(1) but not I(2).

6.5.2.1(c) Step Three: Breakpoints.

Initially, the approach taken in relation to breakpoints was the same as for the private sector, however, meaningful cointegration relations were not to be found for the 'trans-crisis' period. Using the same approach to breakpoint identification as for previous models, the first breakpoint occurred in the mid-1990s in the run-up to the dotcom bubble when the Clinton administration was running a restrictive fiscal policy, the public sector actually ran a fiscal

Series	Type	1960$Q$2 - 2016$Q$4 ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
G	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
Y	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
GD	Level	accept	reject***
	Difference	reject***	reject*
	2nd Difference	reject***	accept

Table 6.5.4: Unit root tests for time series in the Public Sector Model

Source: US IMA
Total Government Expenditure (C:1)
Gross Domestic Product (A:1)
NLB Stock(gov) (A:43)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

surplus for a short time (see figure 4.1.1 (p.161)) which changed the relation between G, Y and GD. Consequently, the remainder of this section will work with just a single time period, up to this time point in 1993$Q$4.

The sensitivity to the choice of lags and breakpoints for the public sector will also be addressed below in section 6.5.2.2, similarly to that for the private sector.

6.5.2.1(d) Step Four: Lags.

The lag order of the VECM is determined in a similar way to that followed for the private sector. For the single time period for the public sector model (1960$Q$2 - 1993$Q$4), the number of lags selected is 5.

6.5.2.1(e) Step Five: VECM Estimation.

The parameter selections were as for the private sector model — the long run form of the VECM, with a trend in the cointegrating vector and with four seasonal dummy variables. The order of cointegration resulted in one cointegrating vector at the 1% significance level.

As with the private sector VAR, the coefficients and standard errors for both periods are listed in tables C.2 (p.396) in Appendix C. The results of diagnostic tests for autocorrelation, heteroskedasticity and normality of the residuals are given in table 6.5.5.

	ΔG	ΔY	ΔGD
Significance of Coefficients F-test: Null Hypothesis, Coefficients = 0			
Period 1	reject***	reject***	reject***
Normality Jarque-Bera Test: Null Hypothesis, Normally Distributed Residuals			
Period 1	accept	reject***	reject***
Autocorrelation Box-Pierce Test: Null Hypothesis, No Autocorrelation			
Period 1	accept	reject**	accept
Heteroskedasticity ARCH-LM Test: Null Hypothesis, Not Heteroskedastic			
Period 1	accept	reject*	reject***

Table 6.5.5: Diagnostic Tests For Public Sector VECM

Source: US IMA
Total Government Expenditure (C:1)
Gross Domestic Product (A:1)
GD is NLB Stock(gov) (A:43)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

In this public sector VAR, the F-test for coefficients jointly insignificant is rejected as before. The Jarque-Bera test rejects the null of normality for the equations in ΔY and ΔGD, due to the elevated readings for kurtosis, 4.81 for the ΔY residuals and 10.21 for ΔGD. The autocorrelation in the Box-Pierce test is less than in previous tests, perhaps due to the higher number of lags. The ACF for Y, for which the null of no autocorrelation was rejected at the 5% level, is shown in figure 6.5.3. As in the previous cases, it indicates that the autocorrelations are not individually highly significant (with the exception of lag 8), however they do exhibit the same low frequency oscillating sine wave pattern as for the system VAR, which was attibuted in those cases to negative coefficients in the underlying AR(k) process, however the important point to note is that the pattern is stationary. The results for the test of heteroskedasticity show rejection of the 'no heteroskedasticity' hypothesis at the 10% level for the ΔG equation and at the 1% level for the ΔGD equation but not rejected for ΔY.

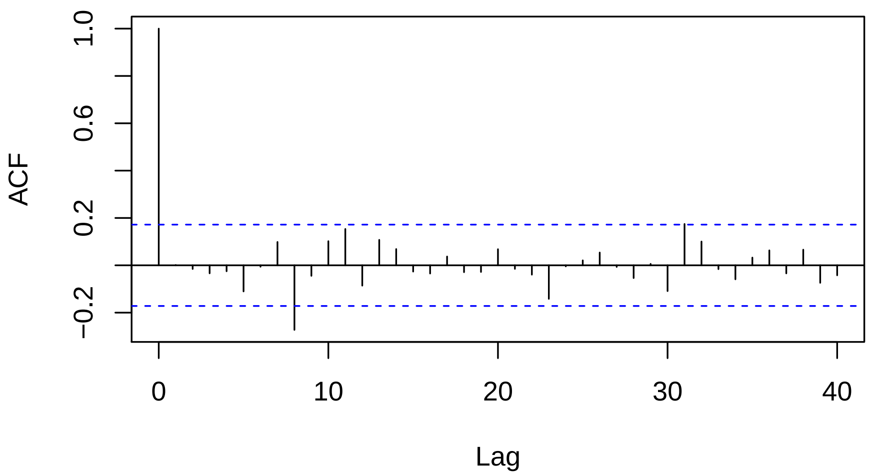

Figure 6.5.3: Public Sector Autocorrelation Function for the residuals of ΔY

These diagnostic tests reveal some areas of concern particularly the kurtosis of the residuals, however these are not considered to be sufficiently serious in this case to invalidate the results of the model since statistical inference on the significance of parameter values is not part of the exercise, which is rather to find cointegration relations between the model's time series to support the hypothesis of the action of partial adjustment processes in the public sector.

6.5.2.1(f) Step Six: Extract the Cointegrating Relation.

The resulting cointegrating relation for the time interval $1960Q2$ to $1993Q4$ with a time trend is,

$$\text{CR:}\ \ G - 0.283Y + 0.123GD - 1.178t$$

and the estimates of the parameters ψ and γ in the partial adjustment process are,

$$1960Q2 \text{ to } 1993Q4 \qquad \psi = 0.123 \qquad \gamma = 1$$

The value of ψ for the speed of adjustment factor of the partial adjustment process 0.123 is a little higher than for the private sector model, but still within reasonable bounds for such a parameter.

The value of γ for the public sector debt-gdp norm that emerges from this calculation is somewhat higher than the actual value for the period at 100% as shown in figure 6.5.4.

The cointegrating relations, with and without time trends are shown in figure 6.5.5. The detrended line appears to pass through three phases, in the first, up to the mid-1970s, the relation is quite stable, in the second, up to the early 1980s, shows a downtrend, and the third during the 1980s-1990s when the relation appears to be mean-stationary but oscillating. The trended line follows the same pattern with an overall downward time trend. The difference between the trended and detrended lines is not as great as in the previous models due to the low value of the coefficient of the trend term in the cointegrating relation.

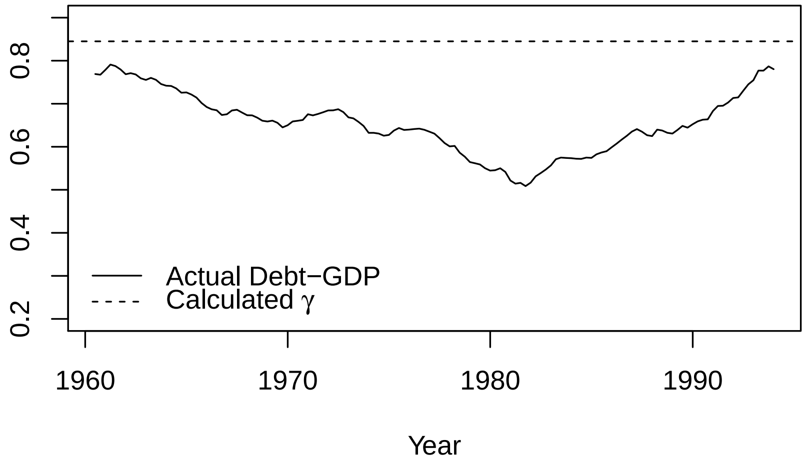

Figure 6.5.4: Actual Debt-GDP ratio for the public sector: 1960$Q$2 to 1993$Q$4

Source: US IMA
Gross Domestic Product (A:1)
GD is NLB Stock(gov) (A:43)
('A:' refers to the line number in table 3.2.8)

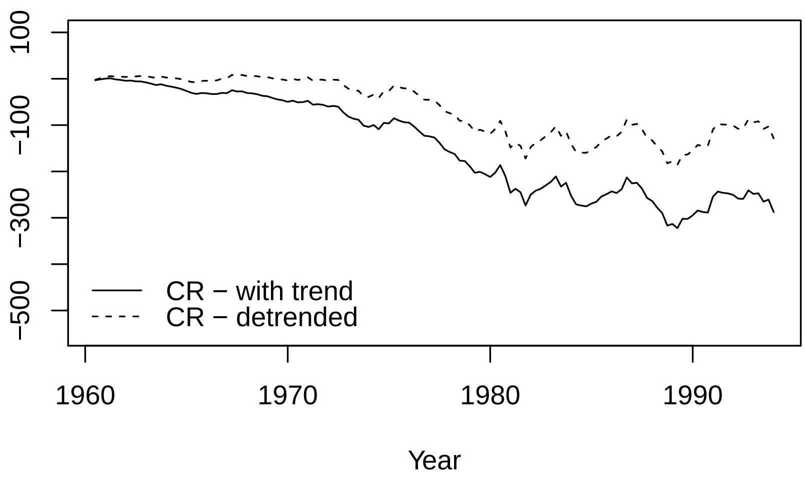

Figure 6.5.5: Cointegrating relations for the public sector VAR: 1960$Q$2 to 1993$Q$4

Source: VECM estimation

There still appear to be 'regime changes' coming through these cointegrating relationships, in the period up to 1980, there is a gradual decline, but with low volatility; after 1980 the mean appears more stable, but the volatility has increased.

6.5.2.2 Sensitivity Analysis: Public Sector Model

As with previous sections, an analysis will be undertaken to vary the breakpoint dates and the number of lags used to estimate them and to see how this affects the outcome, i.e. the order of cointegration, and the values of ξ and η. The lags were varied from 2 up to 6 and the date for the first breakpoint was allowed to range over the interval 1990Q1 to 1996Q4.

The range of potential dates for the breakpoint and the range of lags gave 140 possible combinations. In nearly all cases, the order of cointegration was one. Column 2 of table 6.5.3 shows the results for two cases, with and without a trend in the cointegrating relationship.

Once the order of cointegration is settled, the next consideration is whether the values of the β vector combine to produce meaningful values of γ, the debt-GDP norm, and ψ, the speed-of-adjustment factor. With no trend in the cointegrating relation, the number of combinations producing a meaningful γ was 43 and 36 when the trend was selected, and the same numbers for ψ.

Trend	Cointegration Order			ψ	γ
Type	0	1	2	$0 < \psi < 1$	$\gamma > 0$
No Trend	8	94	38	43/94	43/94
With Trend	26	96	18	36/96	36/96

Table 6.5.6: Sensitivity of Parameters to selection of Lags and Breakpoints: Public Sector
For breakpoints in the interval 1990Q1 *to* 1996Q4 *and lags between 2 and 6, total combinations of 140*

The combinations with positive values of ψ and γ in the 'with trend' estimations are roughly a third which is slightly better than the result for the private sector, but is still not overwhelming in support of the partial adjustment process explanation. On the other hand, the proportion of cases in the 'no trend' estimations that display acceptable values of the partial adjustment parameters is better, $\approx 50\%$ which lends guarded support to the proposition that partial adjustment processes encapsulating stock-flow norms are active in the dynamics of the economics of the public sector.

6.5.2.3 Summary and Conclusions on the Public Sector Model

The results of this section on the public sector model have been very similar to those for the private sector. Again, the objective was to develop a VECM model of the public sector under the assumption that its dyamics are driven by a partial adjustment process incorporating a stock-flow norm in the form of the government debt to GDP ratio. The relevant flows in this case were government expenditure (G), GDP (Y) and the public sector debt (GD). A single cointegrating relation between these time series was found for most, though not all combinations of lags and breakpoints in the period preceding the dotcom bubble, but very few in the period which included the crises; for this reason, only a single estimating period covering the pre-dotcom bubble period was modelled.

The form of the partial adjustment process for the public sector was derived in section 5.2 above as equation 5.5 (p.241),

$$G = (\theta + \psi\gamma)Y - \psi GD_{-1}$$

A sample of time periods prior to the dotcom bubble was formed by identifying a range of possible breakpoints from $1990Q1$ to $1996Q4$. VECM estimates on these time periods provided a set of estimates of the speed-of-adjustment parameter, ψ, and the debt-income norm, γ for lags in the range 2 to 6. The proportion of cases yielding meaningful estimates of these parameters was similar to that for the private sector as table 6.5.6 shows, of the order of 1/2 with no trend in the cointegration relation and around 1/3 for the case with trend. Given that the public sector stocks and flows have been more volatile than the private sector, even in the period preceding the crises, with several changes of public policy, e.g. the restrictive fiscal policies practised in the 1990s, expectations for a clear result for the public sector should be lower. While the evidence for the action of partial adjustment processes has been only partial, it seems reasonable to conclude that this dynamic is present although, as for the private sector, it is clear that there are other dynamics involved.

6.5.3 The Foreign Sector

For the sake of completeness, the same exercise as carried out for the private and public sectors above will be repeated here for the foreign sector. This section is a virtually a rerun of the earlier ones, the same steps will be followed, although now that the pattern is established, some of the detail will be skipped. The objective is the same, to examine the evidence for a partial adjustment process in the foreign sector.

One would not expect foreign sector constraints to be binding on the US economy which prints the world's currency and whose debt the rest of the world seems quite willing to hold, in fact, actually clamours for in times of insecurity.

The stock-flow ratios for the foreign sector were investigated in section 4.2.1.3 where it was found that the ratio of US net foreign assets to income progressed through three phases, from 1960$Q2$ to the early 1980s, the second up to the global financial crisis and the third covering the post-crisis phase. Unit root tests on the ratio in each of these phases showed that it was non-stationary in the first phase, trend stationary in the third phase and the ADF and KPSS tests conflicted in the second phase. In the first phase, the ratio was in a non-stationary growth regime, in the third phase, the precipitous drop in the US IIP following the GFC meant that the ratio was simply following a decline under such a severe deterministic time trend that any stochastic elements in the time series were insignificant by comparison. The fact that the ADF and KPSS tests differ in the second phase (ADF fails to reject the null of a unit root while KPSS fails to reject the null of stationarity) suggests the possibility that the steady decline in the US IIP throughout this period was also governed by a deterministic trend rather than a stochastic one. These speculations will be investigated further now.

The foreign expenditure equation was developed in the form of a partial adjustment process in section 5.2 resulting in equation 5.6 (p.242),

$$X = (\mu + \xi\eta)Y - \xi FR_{-1}$$

This is transformed into the long-run form of a VECM, following the general pattern for the VECM in equation 3.5 (p.136),

$$\Delta \begin{bmatrix} X \\ Y \\ FR_{-1} \end{bmatrix}_t = \Delta \begin{bmatrix} X \\ Y \\ FR_{-1} \end{bmatrix}_{t-1} + \ldots + \Delta \begin{bmatrix} X \\ Y \\ FR_{-1} \end{bmatrix}_{t-p+1} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \cdot [\beta_1, \beta_2, \beta_3] \begin{bmatrix} X \\ Y \\ FR_{-1} \end{bmatrix}_{t-p} + \boldsymbol{\mu} + \boldsymbol{\Phi D_t} + \boldsymbol{\epsilon_t}$$

where the components are the time series X, Y from table 6.2.1 and foreign sector net financial assets (FR) from table 6.2.2; $\boldsymbol{\mu}$ is a vector of constants (empty in this case), $\boldsymbol{D_t}$ is a vector of deterministic components (containing seasonal dummies in this model) and $\boldsymbol{\epsilon_t}$ is a vector of 'white noise' processes. It is written under the assumption that there will be a single cointegrating relationship since $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are shown as 3×1 vectors. The cointegrating relation is captured in the matrix,

$$[\beta_1, \beta_2, \beta_3] \begin{bmatrix} X \\ Y \\ FR_{-1} \end{bmatrix}_{t-p}$$

6.5.3.1 The Foreign Sector Model: Estimation

The six-step procedure will be followed again, but some steps may be skipped.

Unit Root Tests. Table 6.5.4 presents the results of unit root tests on the foreign sector variables for the full period. There is just one point to note, the KPSS test rejects the null hypothesis of stationarity for the differenced FR series. Nevertheless, it will be assumed that all are I(1) but not I(2).

Breakpoints. The breakpoints identifying the three phases of the stock-flow ratio referred to above will be used to define the breakpoints in this model. Since phases two and three are relatively short and, according to the unit root tests in section 4.2.1.3, were I(0) rather than I(1), VECM models will only be estimated for the first phase (1960$Q$2 to 1983$Q$1). An estimation of the whole period 1960$Q$2 to 2016$Q$4 is not considered worthwhile due to the severe

Series	Type	1960$Q2$ - 2016$Q4$ ADF Test	KPSS Test
Null Hypothesis		Unit Root	Stationarity
X	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
Y	Level	accept	reject***
	Difference	reject***	accept
	2nd Difference	reject***	accept
FR	Level	accept	reject***
	Difference	reject***	reject**
	2nd Difference	reject***	accept

Table 6.5.7: Unit root tests for time series in the foreign Sector Model

Source: US IMA
Total Exports (C:7)
Gross Domestic Product (A:1)
FR is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

structural breaks in the series FR.

Lags. The lag order of the VECM is determined for the single time period for the foreign sector model (1960$Q2$ - 1983$Q1$), to be 9.

VECM Estimation. The parameter selections were as for the previous models — the long run form of the VECM, with a trend in the cointegrating vector and with four seasonal dummy variables. The order of cointegration resulted in one cointegrating vector at the 1% significance level. The coefficients and standard errors are listed in tables C.3 (p.397) in Appendix C. The results of diagnostic tests for autocorrelation, heteroskedasticity and normality of the residuals are given in table 6.5.8.

In this foreign sector VAR, there is only a single period, 1960$Q2$ to 1983$Q1$. The F-test for coefficients jointly insignificant is rejected as before. The Jarque-Bera test suggests normality of the residuals except for ΔY (rejected at the 10%

	ΔX	ΔY	ΔFR
Significance of Coefficients F-test: Null Hypothesis, Coefficients = 0			
Period 1	reject***	reject***	reject***
Normality Jarque-Bera Test: Null Hypothesis, Normally Distributed Residuals			
Period 1	accept	reject**	accept
Autocorrelation Box-Pierce Test: Null Hypothesis, No Autocorrelation			
Period 1	reject**	reject***	accept
Heteroskedasticity ARCH-LM Test: Null Hypothesis, Not Heteroskedastic			
Period 1	accept	reject***	accept

Table 6.5.8: Diagnostic Tests For Foreign Sector VECM

Source: US IMA
Total Exports (C:7)
Gross Domestic Product (A:1)
FR is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

level). The autocorrelation in the Box-Pierce test is elevated for ΔX and ΔY even with a rather high number of lags. The ACF for ΔX, for which the null of no autocorrelation was rejected at the 5% level, is shown in figure 6.5.6. There are more lags at which the autocorrelation is significant than in the previous cases, and they also exhibit the same low frequency oscillating sine wave pattern as for the system VAR. The results for the test of heteroskedasticity fail to reject the 'no heteroskedasticity' hypothesis at the 1% level for all equations.

These diagnostic tests are similar to those for the previous models, the next step is to check for potential cointegration relations.

Extract the Cointegrating Relation. The resulting cointegrating relation for the time interval $1960Q2$ to $1983Q1$ with a time trend is,

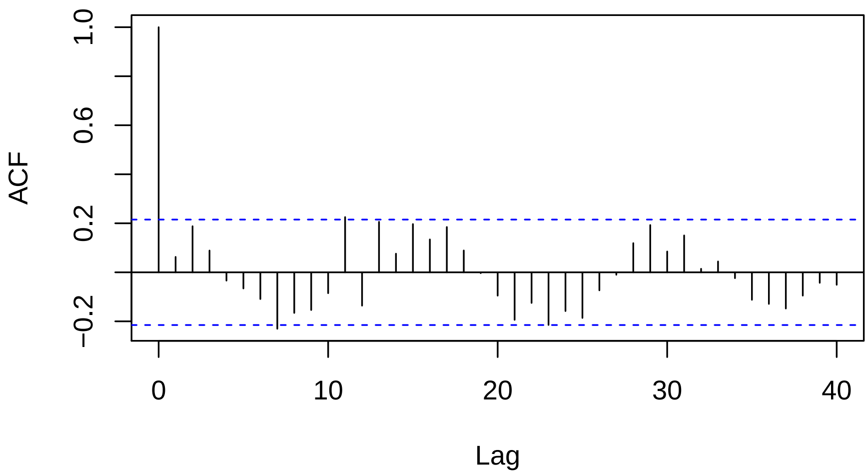

Figure 6.5.6: foreign Sector Autocorrelation Function for the residuals of ΔY

$$\text{CR:} \quad X - 0.152Y + 0.136FR + 0.939t$$

and the estimates of the parameters ξ and η in the partial adjustment process are,

$$\xi = 0.136 \qquad \eta = 0.015$$

The value of ξ for the speed of adjustment factor of the partial adjustment process is higher than for the previous models, but still within reasonable bounds for such a parameter. The value of η for the foreign sector ratio of Foreign Reserves to income bears no relation to the actual value which was in the vicinity of 10% during this period. The cointegrating relation with time trend is shown in figure 6.5.7 which reveals it to be approximately mean-stationary over the period, but unstable with a large and growing variance.

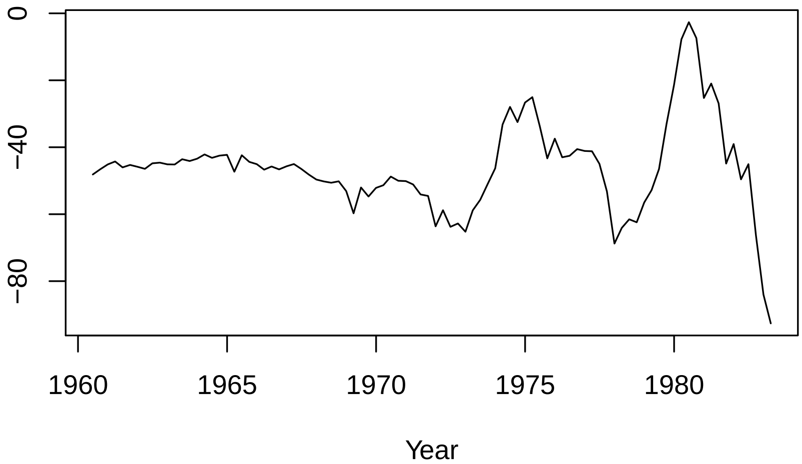

Figure 6.5.7: Cointegrating relations for the foreign sector VAR: 1960$Q$2 to 1983$Q$1

Source: US IMA
Total Exports (C:7)
Gross Domestic Product (A:1)
FR is NLB Stock(RoW) (A:44)
('A:' refers to the line number in table 3.2.8)
('C:' refers to the line number in table 3.2.4)
Significance Levels: '***' 1%, '**' 5%, '*' 10%

6.5.3.2 Sensitivity Analysis: Foreign Sector Model

As with previous sections, an analysis will be undertaken to vary the breakpoint dates and the number of lags used to estimate them to see how this affects the outcome, i.e. the order of cointegration, and the values of ξ and η. The lags were varied from 2 up to 11 and the date for the first breakpoint was allowed to range over the interval 1980$Q$1 to 1987$Q$1, the last quarter where US foreign reserves were positive.

Table 6.5.9 shows the combinations of $\xi : 0 < \xi < 1$ and $\eta : \eta > 0$ for the time periods and lags in the search range.

The table shows that there are few combinations with values of ξ and η which can plausibly be interpreted as parameters of a partial adjustment process.

	Lags									
Period	2	3	4	5	6	7	8	9	10	11
1980$Q1$	$0.57, 0.26$									
1980$Q2$	$0.56, 0.2$		$0.86, 0.21$							
1980$Q3$	$0.6, 0.25$		$0.92, 0.23$							
1981$Q4$				$0.59, 0.2$						
1985$Q2$				$0.67, 0.04$						
1985$Q3$		$0.94, 0.02$		$0.71, 0.04$						
1985$Q4$			$0.42, 0.02$	$0.89, 0.07$						
1986$Q1$		$0.84, 0.02$	$0.42, 0.02$	$0.86, 0.06$		$0.34, 0.03$				
1986$Q2$		$0.76, 0.03$	$0.42, 0.05$	$0.78, 0.05$			$0.37, 0.05$			
1986$Q3$		$0.75, 0.03$		$0.77, 0.05$			$0.33, 0.03$			
1986$Q4$				$0.78, 0.03$						
1987$Q1$				$0.7, 0.01$						

Table 6.5.9: Valid Combinations of ξ and η For Foreign Sector VECM
Data Source: VECM estimation

The combinations shown in the table are those from the search space where $0 < \xi < 1$ and $\eta > 0$, but of those very few are economically credible as parameters — the values of ξ are generally too high for speed-of-adjustment factors and the η are generally too low for stock-flow norms. As stated in the introduction to this section, the likelihood that a partial adjustment process based on a stock-flow norm should be active in the foreign sector of the US economy was always low, and this analysis lends support to that doubt.

6.5.3.3 Summary and Conclusions on the Foreign Sector Model

The results of this section on the foreign sector model have been somewhat more limited than for the other two sectors and while there was cointegration between the foreign sector flows and the stock of foreign reserves, the evidence of the action of a partial adjustment process was not convincing.

Based on plots of the foreign sector stock, three distinct time periods were identified in which quite separate policy regimes were clearly in evidence — firstly, the period up to the early 1980s when the US IIP was positive and growing at a rate comensurate with its rate of economic growth; secondly, the period up to the global financial crisis during which US net foreign assets were steadily declining due to a chronic current account deficit, and finally, the period following the crisis when net foreign assets have been in precipitate decline. For this reason, the VECM modelling activity was confined to the first period. Similarly to the other two sectors, a sample of time periods in the first period was formed by identifying a range of possible breakpoints from 1980$Q$1 to 1987$Q$1. VECM estimates on these time periods provided a set of estimates of the speed-of-adjustment parameter, ξ, and the net foreign assets-income norm, η for lags in the range 2 to 6. Table 6.5.9 gives values of these parameters for combinations of lags and breakpoints in the sample for which an order of cointegration of one was found. Not only was the proportion of cases yielding valid combinations rather low, but the pairs of values returned are not plausible as parameters of a partial adjustment process — the values of the speed-of-adjustment factor are too high and the values of the stock-flow ratio are too low. Historically in this period, the US IIP has been between 5 and 10% of national income.

It would be reasonable to expect that a partial adjustment dynamic encompassing a stock-flow norm based on foreign reserves to be binding on a 'balance of payments constrained growth' economy where the availability of foreign exchange would have significant impact on national income, but not in the US economy where there seems to be no limit to the size of the current account deficits. If there is a feedback constraint between the IIP and income, it follows a different dynamic from the partial adjustment process defined here.

6.6 The Model: Interpretation and Conclusions

This chapter has presented a simple, highly aggregated three-sector stock-flow model and populated it with data from the US economy. The purpose was to investigate, logically and empirically, one of the basic tenets of Godley's economics — that the economy is driven by the level of expenditure represented by the fiscal stance and the trade ratio which drives output via a multiplier process and is stabilised by the action of stock-flow norms (Godley 1983). This is consistent with the broad Keynesian tradition that the level of economic activity, output and employment are essentially demand determined (although they may sometimes be supply constrained). It also incorporates the work of later post-Keynesian writers, notably Minsky, on the importance of stocks and balance sheets in stimulating or constraining economic activity, especially by fixing agents' expectations (Minsky 1975). And the choice of a three-sector model is influenced by work on the *three balances* by the 'New Cambridge' school in the 1970s. The choice of a highly aggregated three-sector model is an example of what in systems science is termed a 'black box model', where only a limited set of high-level flows into and out of the system are studied, abstracting from much of the complexity inside it. There are obviously limitations on what can be learned from such a model, it can possibly answer questions about *what* can or cannot happen, but will not be helpful in answering questions about *how* or *why* they happen, those will require 'opening up the black box'. What is to be expected is that any results found to hold for the highly aggregated model will continue to hold for successive disaggregated models. This is consistent with a *complex adaptive systems* view of a macroeconomy as outlined in section

3.1 and completely at odds with the current received wisdom in mainstream macroeconomics on the need for microfoundations (Wren-Lewis 2018).

The economic stabilisation by the stock-flow norms is viewed here as having its effect through the action of *partial adjustment processes* (section 2.2.2.1) whereby imbalances between the target and actual levels of stocks generate a stimulating or damping effect on related flows. The work of this chapter has been concentrated on the study of these partial adjustment processes by seeking evidence of these effects in data for the US economy. Here, the apparatus was the Johansen cointegrating VECM method (Johansen 1995) as implemented in the 'R environment for statistical computing' (Pfaff 2008b). The cointegrating vector error correction model is a natural fit to the concept of stock-flow stabilisation. It identifies cointegration relations between the non-stationary time series of the model, and splits the coefficient matrix of the error correction term into two sub-matrices α, which assumes the role of the *speed of adjustment* factor in the partial adjustment process, and β which determines the coefficients of the cointegrating relations.

All of this may convey the impression that the economy is being viewed as some sort of automaton, a deterministic system whose fixed relations can be discovered econometrically and simulated computationally. Nothing could be further from the truth, as a reading of section 3.1 will demonstrate. The view put forth there was of an economy as a *complex, adaptive system* (CAS), in the sense defined in complexity science (Moore 2014). One way that this complexity and adaptiveness manifests itself is through the non-fixed nature of the parameters in the functions and relations describing the system. Conventionally, under non-CAS assumptions, the relations between economic variables have fixed parameters which can be estimated econometrically, with standard errors that quantify the 'error' between the estimate and the true value. Alternatively, under a CAS view, parameters are constantly adjusting and adapting, so the standard error, rather than measuring the error between the estimate and its true value, could be viewed as a measure of the variability of the parameter. In the lists of parameters for the sectoral VECM models in section 6.5, it was pointed out that some of the lagged parameters were highly significant while others could be rejected at all relevant confidence levels. Nevertheless, these 'insignificant' parameters contribute to the accuracy with which the model fits the data, rejection of the insignificant coefficients leads to a poorly fitting model. However, if the standard error is viewed not as an indicator of the accuracy of the estimation, but the variability of the parameter, it changes the perception of how the model works, but in practice, changes little else since our confidence in the model results will be the same regardless of whether the uncertainty is due to parameter variability or estimation accuracy.

There were further points in the chapter which supported a non-fixed parameter CAS view, firstly in the discussion of the model with three partial adjustment processes on page 255 of section 5.3 where it was observed that if all variables were endogenous in a homogeneous first-order linear difference equation with fixed parameters, the system would either expand continuously or spiral in to zero. Such a system could, however generate meaningful economic behaviour if parameters are not viewed as fixed, but oscillating and adapting in such a way that the eigenvalues of the coefficient matrix are varying around one, so that the system is alternately expanding and contracting. The second place in this chapter supporting the CAS view was in the sections on the stability analysis of the breakpoints for the sectoral models. There it was observed that small changes in the choice of breakpoint led to large variations in the parameters of the estimated model, which would not be expected if the underlying 'true' parameters were actually fixed.

The main econometric investigation involved the use of the Johansen cointegrating approach to VAR (and VECM) modelling. This proceeded through a sequence of stages. First a VECM of the combined sectors was developed containing the expenditure variables and the stock variables which makes it an empirical version of the difference equations in the logical model with three partial adjustment processes (equation 5.12). As expected, the order of cointegration of the model was three, meaning that there exist three cointegrating relations between the model's time series. The cointegrating relations constitute the error correction terms in the VECM difference equations. They are stationary time series formed by linear combination of the model's non-stationary time series. The fact that each of the expenditure variables is able to be part of a statonary relation with the stock variables of the model lends support to the existence of a stabilising stock-flow relationship in the data. Nevertheless, it is still not possible to infer values for the partial adjustment parameters from the coefficient matrices of the VECM. To make progress on this, individual sectoral VECMs were constructed, taking into account breakpoints in the time series caused by the dotcom bubble and the global financial crisis.

For the private sector, VECMs were estimated for two periods, the first up to the dotcom bubble and the second for the whole period. The results for the second period showed greater variability of the residuals, but overall the derived values for the parameter values of the partial adjustment processes were reasonably consistent, with values for α, the private sector wealth-income norm, being broadly compatible with historical values from section 4.2.1.1, although the value for the whole series combined was very high. For the public sector, the results were more mixed; for the first period leading up to the dotcom bubble and the overall period combined, values for the public sector debt-GDP ratio were around 0.8, slightly higher than historical values from section 4.2.1.2. Alternative flow variables for the public sector are possible — public sector debt to GDP and debt to government income were considered — but it was decided to only proceed with the debt to GDP measure. Finally, the analysis was repeated for the foreign sector using the ratio of net foreign financial assets to GDP. Only a single period was estimated, during the period where the US IIP was still positive; The results for this model were less plausible, possible reasons being the shortened data series and some doubt about whether the external sector of the US economy would actually be constrained by considerations of foreign reserves, given that the US provides the world's currency.

The variability of the results for these sectoral models can be partly understood by the stability analysis that was carried out on each one. The VECM parameters were evaluated for models with different choices of start- and end- points for the intervals, reflecting different positions for the breakpoints, to assess the variability in the values of the parameters of the cointegrating relations which, in turn, determine the parameters of the partial adjustment processes. Small changes in the choice of breakpoints and the number of lags could lead to sudden changes in the order of cointegration and hence to the parameter values. This is rather unsatisfactory as there doesn't seem to be any objectively justifiable way of choosing other than to select a combination that produces the 'expected' result. Overall, it could be concluded that the results of this section are encouraging to the presence of partial adjustment processes in the data, but not too much reliance should be placed on the actual values of the stock-flow norms derived.

Chapter 7

Summary and Conclusions

This chapter provides a summary of the results and the conclusions to be drawn from the preceding chapters. It finishes with a statement of the contributions made by this research and some directions for next steps. The central question introduced in section 1.1.1 is

> to what extent does the dynamic process formed of the flow ratios, the multiplier and the stock-flow norms find empirical support in US national income data in the period 1960 - 2016?

A secondary question arises out of the methodological approach to answering the first, and addresses the extent to which meaningful results can be derived about the behaviour of an economy purely in terms of variables available only at the aggregate macro-level

> is it possible to formulate useful relationships amongst the variables available at any level of model aggregation?

A third relates to the role of the empirical model in interpreting and testing an economic hypothesis; the above description of the methodology suggests that the cointegrating VAR will be used as a most general model of the data in the terms of the Hendry methodology, and Godley's hypothesis should be interpretable within it; conclusions of a qualitative nature should be possible following this experience.

7.1 The Collected Results

The work of this study is summarized here under three main headings corresponding to the three principal areas of investigation — the ratios, the convergence process and the empirical model.

7.1.1 The Ratios

This section briefly summarizes the ratios in a descriptive way, that is, studying each on its own. The interactions between the ratios and national income are treated in the next section.

7.1.1.1 The Flow Ratios

The *flow ratios* studied were the *fiscal stance* (§4.1.1) and the *trade ratio* (§4.1.2); time plots of the ratios showed their relationship to national income which could be traced informally to significant events and turning points in recent US economic history. The main question to be resolved was the choice of time series to be used in calculating the ratios; the fiscal stance depends on the share of government income and the trade ratio depends on the proportion of imports in GDP. A related question is the *form* that equations for imports and government income should take; using an *average* tax/import rate leads to equations of the form, $T = \theta Y$ and $M = \mu Y$; this was shown to be appropriate when considering the whole period, but the use of a *marginal* rate, based on the functional forms $T = T_0 + \theta Y$ and $M = M_0 + \mu Y$ fits the data better in specific sub-periods.

7.1.1.2 The Stock-Flow Ratios

The study of the *stock-flow ratios* focussed mainly on the various forms of the wealth-income norm for each of the sectors of the three sector model to be studied in later chapters. The main objective in this section was to assess whether or not each ratio would qualify as a norm, using time-series stationarity as a criterion.

The concept of a stable stock-flow ratio captures the idea that the action of a stock in a flow system will smooth out shocks to the flow by absorbing surges and compensating for troughs in the flow. This principle can be seen in action everywhere, from capacitors to flood plains. For example, the stock of net financial assets of the private sector fulfils this role of a 'shock absorber' for fluctuations in the private sector surplus, which is private sector net saving. If private expenditure rises roughly in line with disposable income in a growing economy, then the ratio of net financial assets to disposable income will be stationary; fluctuations in the ratio will reflect its surge-absorbing action. However this action operates within limits and depends on the presence of a 'small and stable balance', underlying structural changes will cause the ratio to shift to new levels. Bearing these principles in mind, the following paragraphs summarize what was actually observed in the course of the study.

For the private sector, three candidate ratios were considered; in all cases it's clear that the ratio is not mean-stationary across the whole period, and this would not be expected given the regime changes that have taken place in the US economy over this time interval. In fact, the ratios are virtually never mean-stationary, but they all have extended times when they appear to be trend-stationary. Godley & Cripps (1983) state that the norms may be subject to structural changes in the economy and dependent on interest rates. The inverse correlation between the long-term interest rate and the 'NLB stock' ratio was quite noticeable (Fig.4.2.6), and the two series were found to be cointegrated (Fig.4.2.7). However, in other cases the appearance of trend-stationarity was not confirmed — tests on the detrended series still showed the presence of a unit root. The 'NLB stock' ratio in the period up to the mid-1980s was the only one to pass both the ADF and the KPSS tests for stationarity and hence was selected as the representative private sector wealth-income ratio.

The outcome was similar for the public sector. Two ratios were considered, one based on GDP, the other on total government income; both exhibited periods of stationarity which were invariably broken abruptly by each economic downturn. During periods of recession, government revenue is affected often more severely than other quantities as the events around the global financial crisis demonstrated. These events generate large and long-lived deviations, but there appears to be a tendency to revert to previous levels, clearer in the case of the ratio based on government income than GDP. In conclusion, the hypothesis of a stable wealth-income norm in the public sector was accepted for the period leading up to the global financial crisis but not for the entire period (table 4.2.1.2(b)).

Foreign sector wealth-income ratios were calculated using net foreign assets relative to GDP and exports. In neither case was the mean-reverting behaviour expected of a norm to be observed. This could be attributed to the unique position of the US economy as printer of the world's currency and issuer of the world's 'safe asset'. Behind the concept of stock-flow norms is the assumption that a stock cannot expand indefinitely relative to its related flows, but there seems to be no limit to the extent to which the world is prepared to hold US debt. This is not necessarily a refutation of the stock-flow concept itself, but a recognition that it is not driving the dynamics in this case.

Concerning the change factors related to stock-flow norms, the original empirical observation that gave rise to the notion was the 'small and stable private sector balance', which is the pre-requisite for stable ratios; this was in evidence in the 1960s and early 1970s in the UK, with a similar phenomenon in the US at the same time (figure 4.2.1), but not since. The volatility that started with the collapse of the Bretton Woods arrangements and the oil price shocks, has continued to grow with the financialization of the economy through the Volker deflation, the dotcom bubble and the global financial crisis; this has meant that 'norm-like' behaviour may be observed for short periods, but tends not to persist. In many cases the ratios display a time trend, but unit root tests on the detrended series still indicate non-stationarity. A systematic identification of the factors that cause the ratios to change, has not been undertaken here except to note the relationship with the long-term rate of interest in the case of the private sector (Fig.4.2.7). Also, Modigliani's life cycle hypothesis asserts that growth in disposable income leads to a declining wealth-income ratio, which may explain some of the variation.

So can we conclude that the stock-flow principle is only useful in times when the balance *is* small and stable? On the contrary, the fact that Godley was able to use the principle to help identify his *Seven Unsustainable Processes* (Godley 1999c) suggests that stability of the norms may be as useful in its absence as its presence.

Another possible conclusion is that full stationarity of time series may be too strong a criterion for some purposes to which stock-flow norms will be put. There are four general outcomes of stationarity tests on time series:

Fully Stationary no unit root, no time trend, constant mean and variance;

Trend Stationary no unit root, with time trend, time-dependent mean, constant variance;

Random Walk unit root, no time trend, constant mean, time-dependent variance;

Random Walk with Drift unit root, with time trend, time-dependent mean, time-dependent variance;

It may be that, for some purposes, one of the lesser criteria for stationarity might be acceptable. Tests on some of the wealth-income series after detrending still revealed the presence of a unit root and therefore, a time-dependent variance. This would preclude any analysis depending on statistical inference, however, the mean-stationary properties of the series may still be informative.

Alternative explanations for the emergence of stock-flow norms were investigated (§2.2.1.4) and these included Modigliani's *Life Cycle Hypothesis* (LCH) which offers a microeconomic explanation for the private sector wealth-income norm that has clear macroeconomic consequences, and Phillips' Proportional-Integral control process from systems theory which shows that they can successfully be explained as *emergent* properties of the dynamic behaviour of the economic system, showing that it is not necessary to assume microfoundations for the existence of stable stock-flow ratios.

The conclusion then is that the concept does not require microfoundations; it is not necessary (or even plausible) that individual agents have target stock-flow ratios. The effect *emerges* from the combined behaviour at the macro-level. Phillips' Proportional-Integral control process provides an example of how stable wealth-income ratios can emerge without any micro-assumptions whatever. Modigliani's Life Cycle Hypothesis *does* assume that individual agents attempt to smooth income and expenditure over a whole lifetime, rather than just each budget period and this *is* a micro-assumption, but does not assume that wealth-income norms appear at the macro-level because individual agents have wealth-income norms; the wealth-income norms emerge at the macro-level as consequences of the composition over the whole economy of the various income-expenditure smoothing strategies of the individual agents.

The overall conclusion on these sectoral stock-flow ratios is, firstly, that they will be stationary when the corresponding sectoral balance is stable, secondly, the main change factor is the volatility in the sectoral balances but there are others, for example, the rate of interest and, thirdly, that they are a systemic phenomenon, not a behavioural one, they emerge at the macro level but do not necessarily exist at the micro level.

7.1.2 The Convergence Process

The purpose of studying the ratios was to understand their role in the dynamics of the economy. The central hypothesis being examined is the assertion that the flow ratios drive national income through a multiplier process under the regulating influence of the stock-flow norms, and that this dynamic process will cause national income to converge on one of the flow ratios. This is the *flow ratio–multiplier–stock-flow norm* dynamic which is called the convergence process here, it concerns how the convergence happens and which of the flow ratios income will converge to.

7.1.2.1 The Flow Ratios as Drivers

The assertion that the flow ratios act as drivers of the national income concerns the first two components of the convergence process. The first test of this hypothesis (§5.1) was the estimation of a Johansen VECM model between the fiscal stance and income, and also between the trade ratio and income which established a cointegrating relationship between the flow ratios and the national income. Cointegration entails Granger-causality and to determine in which direction the 'causality' runs, Granger tests were conducted which showed that, for up to eight time periods from a 'shock', it is changes in the fiscal stance that are 'Granger-causing' changes in national income, but changes in national income are not 'Granger-causing' changes in the fiscal stance, implying that the changes in the fiscal stance *lead* changes in income.

In light of this result, a conclusion that the flow ratios are drivers of the national income seems well supported.

7.1.2.2 Existence of Partial Adjustment Processes

The second part of the convergence process is the assertion that the stimulus to income from the flow ratios is stabilised by stock-flow norms. These are assumed to act through partial adjustment processes in which the speed of adjustment factors and the stock-flow norms combine to determine the trajectory towards closing the gap between the flows. One partial adjustment process was defined for each sector incorporating the relevant stock-flow norm; based on expected values for these norms and the speed of adjustment factors, the dynamic action of the partial adjustment processes was simulated computationally (§5.5.1).

These simulations show what behaviour is expected under the assumption of the action of partial adjustment processes, but empirical support for these assumptions falls to the sectoral VECMs (the subject of section 7.1.3 below).

7.1.2.3 Convergence under the Multiplier

The previous two points combine to produce convergence of the national income towards one of the flow ratios. The original assertion about the convergence process was made by Godley in the context of a model of a closed economy. This was translated into a three sector model by deriving a new version of the multiplier. The flow ratios themselves were shown to be examples of *partial multipliers* and, when combined with assumptions about the action of stock-flow norms, could be merged into a *complete multiplier*, in which the *multiplicand* consists of the period's opening stocks for each sector (§5.2).

A series of simulations performed on the three sector economy using this multiplier under various assumptions about the flow ratios showed that the subsequent behaviour of the system depends on which of the flow ratios is free to adjust (§5.5.1). If two ratios are fixed, national income converges to the third; this will not be a stock equilibrium (Fig.5.5.1). The common example of this is where the private sector is balanced and the other two have equal and opposite balances, either *twin deficits*, if the fiscal stance exceeds the trade ratio, or twin surpluses otherwise. If two sectors are free to adapt, national income converges to the third (fixed) ratio. Common examples are firstly, the 'Maastricht' scenario, where the fiscal stance is fixed (the Maastricht criteria require Eurozone states to limit deficits to a maximum of 3% of GDP) and national income converges on the fiscal stance (Fig.5.5.3); secondly, the *Balance of Payments Constrained Growth* scenario, described by Thirlwall's law, has the trade ratio fixed; in this case, national income converges on the trade ratio (Fig.5.5.2).

These various behaviours induced by the relationships between the flow ratios leads to a classification of economies into 'surplus' — those tending to run current account and/or budget surpluses, whose trade ratio exceeds the fiscal stance — and 'deficit' economies, those tending to run deficits, whose fiscal stance exceeds the trade ratio. Once this classification is established, the actual outcome for the economy will depend on the position of national income in relation to the flow ratios. This classification was illustrated with examples from European economies based on Eurostat data (§5.7). The surplus economies showed clear convergence to the fiscal stance (Fig.5.7.1). The deficit economies tended to converge to the CFTR (Fig.5.7.2). But there were a group of economies, labelled 'mixed', that didn't converge to any of the flow ratios, their income being persistently lower than all three (Fig.5.7.3). Deeper investigation would be required to understand why income does not converge as expected;

one speculative explanation was that they might be ‘income constrained’ in some way; with fixed fiscal stance and trade ratio, private expenditure needs to expand to increase income to allow convergence. This leaves a question mark over the convergence assumption pending an explanation of the reasons for non-convergence of these ‘mixed’ economies which could be resolved through further research.

7.1.2.4 Disequilibrium Dynamics

The multiplier expression was translated into a linear difference equation defining the expenditure flows for the three sectors altogether in terms of their opening stocks. This equation effectively encapsulates the first stage of the stock-flow dynamic, that “opening stocks determine flows” (Eqn 5.12). The second stage “flows update stocks” was also incorporated to yield a second difference equation determining closing values of stocks for the period in terms of their opening values (Eqn 5.14).

The fact that all variables in the second equation are endogenous means that it is mathematically unstable. It models the *disequilibrium dynamics* of the economy but, because there are no exogenous variables, there is no steady state. This formulation of the equation only works under the assumptions of the economy as a *complex adaptive system.* If the coefficient matrix, which contains the speed of adjustment factors, the stock-flow norms and the tax and import rates, is constant, there are three possible trajectories for the stocks; they can increase without limit, they can decay to zero, or they could stay constant (in the special case where the eigenvalue of the coefficient matrix is one). None of these possibilities reflects the behaviour of a real economy which fluctuates from growth to recession, usually on a steady long-term growth path. However, such behaviour can be displayed by this equation under the complex systems assumption of non-fixed parameter values. A simulation, starting from a full stock equilibrium and slightly varying the speed of adjustment factors, showed the oscillating behaviour typical of the business cycle (Fig.5.5.4).

This is not sufficient to conclude that the US economy is a complex adaptive system, which remains an assumption, but it does help to understand the random variation in the parameter values.

7.1.2.5 The Three Sector SFC Model: The Systems Approach

A three sector SFC model of the US economy was defined in a highly aggregated form (table 6.1.1); since the purpose was to study the evolution of the sectoral surpluses in relation to related flows, the only transactions included were those inter-sectoral flows that are required to determine the sectoral totals; so government expenditure G and government income T for the public sector; exports X and imports M for the foreign sector. Since G, T, X and M are captured in the flow ratios, G/θ and X/μ, it follows that from the flow ratios alone, the balances of those two sectors can be determined, and hence also the private sector balance by appealing to the three balances identity. But at this level of aggregation private expenditure PX is not an inter-sectoral flow, it is internal to the private sector. But without it, the model is not capable of deriving the level of national income, Y; these variables are added as '[memo items]'. What this means is that, once the flow ratios are determined, the private sector balance is fixed, irrespective of the level of PX; in fact, any particular private sector balance is compatible with an unlimited number of combinations of PX and Y. One could say that Y is a function of PX, given the levels of the flow ratios. It is this simple observation, which is a direct consequence of the national income accounting identity, that is the origin of Godley's assertion that it is the flow ratios that act as drivers of the national income.

As well as providing a vehicle for testing the convergence process, this SFC model also provided an example of the 'black box' methodology alluded to in the introduction, namely, a model formulated entirely in terms of macro-level variables at a certain level of aggregation which is *complete* at that level, without requiring access to lower level detail. While there is a limited amount that can be said with so few highly aggregated variables, any results obtained at this level will continue to hold at lower levels as the model is disaggregated.

As an illustration from this model, it was shown above that there is an unlimited number of combinations of PX and Y that are consistent with any particular private sector balance determined by the levels of the flow ratios; but that doesn't mean that all those levels of PX are *possible*, just that they are consistent. At this level of aggregation, the relationship used to determine PX was equation 5.4 which is derived from the assumption of the existence of a partial adjustment process for private sector net financial assets incorporating a wealth-income norm. It is a macro-equation being formulated entirely in terms available at this level of aggregation, but will be superseded in a disaggregated model as other information becomes available. In this case, the same model with a disaggregated private sector, where households, firms and the financial sector become separate sectors, *net lending to firms and households* is now an inter-sectoral flow and this turns out to be a major determinant of PX at that level. The PX equation estimated here in terms of YD and FA is transformed into a function of YD, FA and NL (net lending) in the disaggregated models in Godley (1999c), Zezza (2009), Martin (2012).

The reason for this emphasis on levels of aggregation is to defend the practice of modelling purely in terms of macro-variables, in opposition to the micro-foundations approach where a macro-model is an aggregation of individual behaviours. It can be concluded on the basis of the experience with this model that meaningful analysis is entirely possible at an aggregated level.

7.1.2.6 Growth

The simulations of the convergence process assumed no growth and convergence was to a stationary state. However this was for simplicity of exposition, not because the analysis is only applicable to a stationary economy as appears to be the contention in Shaikh (2012). Martin (2012) develops an empirical model of the New Cambridge equation under the assumption of steady growth. The original estimation of the New Cambridge equation (Cripps & Godley 1976) was estimated in *nominal values* also in the presence of growth.

The empirical models in chapter 6 were also estimated in nominal values with economic growth. This was captured by the inclusion of a time trend in the cointegrating relations from which it can be concluded that the convergence process applies equally in a growth economy.

7.1.3 The Empirical Model

Having established some support for the convergence process through the logical analysis summarized in the preceding section, the next activity was to populate the SFC model with data to test it empirically. The three sector SFC model was populated with quarterly data from the US IMA covering the period 1960 - 2016. Consequently, every cell in the transactions matrix and the balance sheet, represents a time series (table 6.2.1).

The first VECM estimated was the Expenditure Flow model (§6.4.1), which identified three cointegrating relations, each capturing long-run stable relationships between the expenditure flows and the opening values of the stocks. The estimated VECM could be compared with the linear difference equation for expenditure summarized in section 7.1.2.4; its coefficients are combinations of the parameters from the coefficient matrix of equation 5.12. However, since this contains all three sectors combined, there is insufficient information to evaluate the parameters individually, which proceeded through the estimation of separate VECMs for each sector, so that the partial adjustment processes could be estimated individually.

7.1.3.1 The Private Sector VECM and the New Cambridge Equation

The private sector model was a VECM relating private expenditure PX, disposable income YD and private sector net financial assets FA. There was a single cointegrating relation representing a long-run stable relationship between these variables. By interpreting the relation in terms of a partial adjustment process, estimates of the speed of adjustment factor and the wealth-income norm could be calculated; the results were comparable to the empirically observed values from the ratio analysis reported above.

The partial adjustment process for the private sector generates an equation for private expenditure, hence it invites comparison with the *New Cambridge* equation for aggregate private expenditure (§6.5.1.2). Several versions of this are available: the original, estimated by Cripps & Godley (1976); an estimate for the US economy derived from the Levy Institute SFC model (Zezza 2009), and an estimate by Martin (2012) based on a reconstruction of the UK Flow of Funds accounts.

In making a comparison, one issue is the level of aggregation discussed above. The private sector partial adjustment process emanates from a three sector model relating private expenditure to disposable income and the level of net financial assets. All of the others are estimated from disaggregated models which include a lower level variable, net lending to the private sector, which is an *intra-sectoral* flow in the three sector model; this issue was discussed earlier in section 7.1.2.5. The two equations are incomparable on the basis of estimates of coefficient values, but compare favourably in terms of 'fit' to the data; an out-of-sample comparison has not been undertaken.

In conclusion, the VECM estimation supports the existence of a long-run relationship in the private sector relating expenditure to disposable income and net financial assets. Furthermore, when interpreted as a partial adjustment process, the coefficients of the relationship yielded plausible values for the speed of adjustment factor and the wealth-income norm.

7.1.3.2 The Public and Foreign Sectors

Continuing this process with a VECM for the public sector, a single cointegrating relation between the public sector variables was found for some combinations of lags and breakpoints up to the global financial crisis, but the relationship was not clear in the post-crisis period (§6.5.2.1). This is to be expected since the public sector balance was severely impacted by the crisis and its aftermath. Interpreting the public sector cointegrating relation as a partial adjustment process resulted in a value for the debt-GDP ratio slightly higher than the historical actual (Fig.6.5.4).

For the sake of completeness, a VECM for the foreign sector was also estimated (§6.5.3), although it wasn't expected that foreign sector constraints would be binding on the US economy which prints the world's currency and whose debt the world seems eager to hold. Nevertheless, a single cointegrating relation was found, however when interpreted as a partial adjustment process, the value of the stock-flow norm was a poor match to the actual.

In conclusion, the empirical estimation of the partial adjustment processes provided support in the case of the private sector, limited in the public sector but not significant in the foreign sector. This result exactly mirrors the findings reported above concerning the presence of stock-flow norms (section 7.1.1.2). So it could be concluded that, where stock-flow norms are active, their effect is brought about through the action of partial adjustment processes.

7.1.3.3 The Data First Approach

The approach followed here of formulating cointegrating VECMs from the time series of the SFC model is an example of the *data-first* methodology (Hoover *et al.* 2008). Rather than postulating behavioural relationships between the variables, as in a *theory first* approach, these time series were assembled into a Johansen cointegrating VECM which, in terms of the Hendry methodology, represents a model of the Data Generating Process (DGP), in which rival theory models can be interpreted and tested. The theory model under test here is the existence of partial adjustment processes and the convergence process.

The data-first principle implies that there exists a 'true' model of the data which can be discovered by a process of general-to-specific modelling, selection of optimum lag lengths and break point analysis to yield a stable statistical model with white noise residuals which will be representative of the underlying DGP. This wasn't the experience in this case, the existence of cointegrating relations in these models was highly sensitive to the choice of lags and breakpoints. A cointegrating relation covering a period could disappear entirely in the very next quarter and reappear in the following one; or it could vanish if the choice of lags was increased by one but reappear if it was increased again. The sensitivity to choices of lags and time period was not smooth and continuous but erratic and apparently random. Any attempt to say what is the 'true' relationship becomes somewhat arbitrary. This might be understood in two ways; firstly, by looking back to the results of the simulations which showed that the sectoral partial adjustment processes were not all active at the same time, and the behaviour was different depending on which ones were active. The US is a *twin deficits* economy, suggesting that the fiscal stance and trade ratio do not adjust; this is not a stock equilibrium so government debt and the IIP are steadily growing, and national income tends to converge to a stable private sector balance. This would partly explain why the evidence for a partial adjustment process for the private sector was plausible but that for the public and foreign sectors was erratic. However this still doesn't help to understand why the parameters for the private sector VECM were also erratic with changes to lags and breakpoints.

The second possible interpretation of the seemingly random nature of the order of cointegration may be found in the non-fixed parameter values of a complex adaptive system discussed in the previous section. If parameter values for these aggregate relationships are not fixed values with some estimation error, but randomly drawn from some distribution, it would be easier to understand why they do not vary smoothly as lags and breakpoints are varied, but jump discontinously. Of course, all the usual issues of data quality and estimation errors must also be factored in.

The consequence is that model selection in this case was still goal-driven — an order of integration of one was required for the sectoral models, so the model was chosen from among those with this value; others that were rejected may have had equally good properties in all other respects but were not selected because they didn't give the expected result. The model selection strategy used here consisted of evaluating a set of models covering a certain time range and varying the lags within a range, then examining the properties of the resulting models to see how they varied across the space. This is an informal procedure, but gives some confidence that the chosen model is not an 'outlier', but is typical of the models in the range. The sections on *Sensitivity Analysis* (§6.5.1.3, §6.5.2.2 and §6.5.3.2) provide an indication of the proportion of combinations of lags and breakpoints giving models with the expected properties.

Despite these concerns, experience with the approach has been positive; Hendry & Doornik (2014) advocates automated model selection with a software-based environment to support it; an investigation of the application of that approach to this problem would be a challenging test of the concept.

7.2 Contributions

Having summarized the results and drawn some conclusions on the key issues in this research, this section will now summarize its contributions to the literature and to the knowledge in this field.

Analysis of Stock-Flow Norms: The stock-flow norm concept has scarcely been adopted in the SFC and post-Keynesian literature. The idea was introduced in Godley & Cripps (1983) as an *axiom* of their macroeconomics, something that is self-evident and requires no further explanation — they likened it to an *exogenous variable*, something determined outside of the model. Shaikh (2012) says that it was merely an attempt to provide a theoretical explanation for the empirical observation that the UK private sector balance was small and stable. By the time Godley & Lavoie (2007c) appears, only the private wealth-income norm is mentioned and then as a derived ratio from a Modigliani consumption function involving a consumption out of wealth term. The dynamic implications of the ratios are not emphasised. Godley & Cripps (1983, p.42) declared "we admit without reservation that if stock-flow norms were to move about too wildly, most of the theory [...] would be rendered useless". As figure 4.2.1 shows for the US economy, the norms did start to move about very wildly in succeeding decades and perhaps that is the reason why the concept fell out of favour.

This research provides a new perspective on stock-flow norms and macroeconomic ratios more generally by associating them with the dynamics of the economy and identifying the separate but complementary roles of the flow ratios and the stock-flow norms. The underlying hypothesis is that there is a dynamic process whereby the flow ratios act as drivers and the stock-flow norms act as stabilisers in the determination of economic output. For this process to prevail, the ratios must continue to exert an effect even in the presence of volatility.

The first contribution is a review of the historical evolution of the ratios; in the case of the flow ratios, their relationship with national income was explored through Granger tests and found support for the first part of the dynamic process — that the flow ratios are drivers of the national income. in the case of the stock-flow ratios, their stability was investigated through the concept of time series stationarity.

The second contribution is an inquiry into the *nature* of stock-flow norms. Godley & Cripps (1983) assert that they are exogenous macro-variables, and yet at the same time provide a micro-explanation in terms of targets for financial wealth of individual agents. Following Shaikh (2012) cited above, one could say that they are simply a Kaldorian stylised fact, an empirical regularity requiring a theoretical explanation. Modigliani's Life Cycle hypothesis implies that they are a macro-property which emerges from consumption-expenditure smoothing behaviour at the micro-level. Phillips (1954) takes a systems view of the economy and applies a proportional-integral control scheme to aggregated income-expenditure patterns based on the fact that stocks embedded in a flow system will act as a buffer, smoothing out surges and troughs in the flow.

The contribution of this research is to acknowledge that each of these explanations has merit, but that it is not necessary to favour any particular mechanism; rather it offers a complex systems view in which the action of the norms is an *emergent* macro-property. As a macro-phenomenon, they can be quantified and incorporated into macro-models as components of a dynamic system without having to assign micro-explanations. This was demonstrated in the estimation of the sectoral VECM models where a model of the data for each sector was estimated and evidence for the action of the norms inferred by attempting to interpret a partial adjustment process within the data model. Rather than being assumed, the norms are found to emerge from a pure data model of the sector.

The Stationarity Criterion: Related to the contributions to the stock-flow norm concept, was an associated contribution on alternative qualifying criteria for norms. The first essential was to clarify the terminology surrounding them. In their discussions of norms, Godley & Cripps (1983) defined them informally, stating that they were ratios of stock variables to their associated flow variables and, although they could vary, they were 'roughly stable'. By distinguishing in this work between the ratio and the norm, some confusion is avoided. The stock-flow ratio varies with the up-surges and down-surges in the associated flow, but whether or not the combination constitutes a norm depends on the pattern of behaviour that emerges. It is expected of a norm that the ratio should be mean-reverting, so its time series is mean-stationary with a constant variance — a stationary time series — and the norm would be the (constant) mean of the series. So the stock-flow ratio varies about its constant mean (the stock-flow norm), but can the norms also vary? There are two main ways in which the norms change — structural breaks in the time series and trending behaviour of the time series. Godley & Cripps (1983) conceded that the wealth-income norm could change as structural conditions in the economy change; this would create a structural break in the time series and the ratio would then move to varying about a new constant mean. They also mentioned that norms could be dependent on the interest rate and this was illustrated in figure 4.2.6 where the two time series turned out to be cointegrated. In such a case, the ratio is varying about a trend which is driven by an exogenous variable — the interest rate in this case. The expectation is that the stock-flow ratio, once detrended, will be stationary, i.e. without a unit root. In such a case, the challenge is upon the modeller to identify the exogenous variable that is driving the time trend. However, where ratios from this study were detrended, the resulting series still contained a unit root, so there are two trends — a deterministic time trend driven by some exogenous variable, and a stochastic trend — so there are two challenges on the modeller — to identify the exogenous variable driving the time trend and possibly, to identify the time series sharing the stochastic trend with which the ratio might be cointegrated.

These findings from this research offer a novel perspective on stock-flow norms and position the concept firmly within the realm of dynamic econometrics (Hendry 1995) and complex systems theory as already outlined above.

The Flow Ratio–Multiplier–Stock-Flow Norm Dynamic: The dynamic process whereby the flow ratios drive national income through a multiplier process under the stabilising influence of the stock-flow norms was summarised in section 7.1.2. Godley proposed that the first part, concerning the flow ratios and the multiplier, was how Keynes viewed the dynamics of the economy; the second part, the stabilising stock-flow norms, was his extension to make a complete dynamic system of the Keynesian model.

The contribution of this research in respect of this process is to explore its implications and to validate it empirically. The dynamic process was formulated as a partial adjustment process capable of computational simulation. Borrowing the concept of a complete multiplier from Leite (2015) and extending it with the stock-flow norms led to a multiplier expression which encapsulated the dynamic process. Simulations using this multiplier allowed an exploration of the convergence paths to different flow ratios depending on their relative magnitudes and adaptiveness. While other computational SFC models, e.g. Godley & Lavoie (2007c) trace out a dynamic path driven by shocks applied to exogenous variables, the novel contribution was to show convergence to the flow ratios under the constraints of the stock-flow norms.

The additional contribution in this area was the search for empirical support for the existence of this process. The fact that partial adjustment processes could be inferred from the sectoral VECMs and that plausible values for the speed of adjustment factor and the norms were calculated, is a positive outcome for this dynamic process and a new result in the literature on Keynesian dynamics.

Surplus and Deficit classification: Arising from the previous discussion of the dynamic process was a novel classification scheme for whole economies determined by the relationships between the flow ratios and the national income. This is summarised in section 7.1.2 above. The importance of the relationship between the fiscal stance and the trade ratio for overall economic outcomes was pointed out by Godley & Cripps (1983, p.296) and is discussed in Lavoie (2014, p.516), but is limited there to a discussion of the twin surplus - twin deficits scenario, the taxonomy developed here is more comprehensive.

The new contribution of the approach shown here is to normalize all of the ratios and the national income by the CFTR, which is the balancing condition for the private sector, and by co-plotting them, to be able to visualize the convergence of the national income to whichever of the three ratios is dominant. Out of this emerged repeatable patterns which led to a classification of surplus and deficit economies, and the identification of 'mixed' economies which didn't converge to any of the ratios. A speculative explanation that they might be 'income-constrained' could be the subject of further investigation and this could potentially illustrate the usefulness of the contribution of this classification scheme.

The Role of Fiscal Policy: The findings concerning the 'Flow Ratio–Multiplier–Stock-Flow Norm Dynamic' discussed above (p.7.2), also called 'Godley's hypothesis', have consequences for the role of fiscal policy, particularly in the post-crisis recovery. The 'New Consensus' model (Woodford 2009), which is the currently accepted standard for policy makers, accords no role to fiscal policy, monetary policy can do it all; this exclusive role for monetary policy as the main instrument of economic stablisation policy has been critically examined by post-Keynesian authors, for example in Arestis & Sawyer (2004), while at the same time challenging the reduced role accorded to fiscal policy (Sawyer 2011, Arestis & Sawyer 2011b, Lavoie 2006). According to the new consensus view, fiscal expansion merely leads to higher inflation and higher interest rates and has no effect on economic outcomes (Fontana & Passarella 2016, p.5). The correct role of fiscal policy is to maintain balanced budgets, preferably with low levels of taxation, to avoid 'crowding out' private sector investment. While there are many variants on this narrative, even among 'mainstream' economists, it remains a default assumption in many current macroeconomic policy prescriptions - the 'Washington consensus', the Eurozone's stability and growth pact, the Labour Party's proposed fiscal rule, for example, and has been used as a justification for post-crisis austerity policies (DeGrauwe & Ji 2013).

The findings in section 5.1 of a cointegration relationship between the fiscal stance and national income and in particular, that fiscal stance *leads* national income, coupled with the findings from the VAR analysis of a cointegration relation capturing the partial adjustment process implied by the dynamic in Godley's hypothesis all suggest that mainstream assumptions about the role of fiscal policy may not be consistent with the empirical evidence.

The Data-First Approach: The data-first approach to modelling (Hoover *et al.* 2008) as used here was summarised in section 7.1.3, page 371. The application of this approach to and SFC model is an original contribution both to the SFC and the data-first literature. The main application of SFC models so far has been out-of-sample projections of economic outcomes over a medium-term future. This requires computational models, and the parameterization of these models may be accomplished by econometric estimation, calibration or stylised facts (Caverzasi & Godin 2014, Nikiforos & Zezza 2017). This study is different; its purpose is not forecasting or projection, but understanding of intrinsic economic processes; rather than postulating theoretical relationships between variables and using econometric methods to parameterize them, it uses in-sample data to produce a statistical model of the DGP in which the hypothesized process can be interpreted.

The description on page 371 explained some of the difficulties encountered in applying the principle to an SFC model, but despite these challenges, this approach shows itself to be a worthwhile addition to SFC modelling techniques.

A Systems Approach: This research shares an objective with Godley & Cripps (1983, p.41) which is to understand how “whole economic systems function”. The objective is to be able to model system behaviour at different levels of aggregation, solely in terms of variables that are available at that level. The concept of black-box analysis from systems theory characterises this approach. It involves gradually revealing more of the detail as the outer layers are peeled away. This contrasts with current practice in macroeconomics where models must be ‘microfounded’, “...no relationship between aggregates [...] can validly be postulated which cannot be justified precisely in terms of the behaviour of individual agents. Such a view seems perilously close to a denial that macroeconomics (the study of how whole economic systems function) can be a valid subject at all” (Godley & Cripps 1983, p.41).

The way that this approach was applied here, was to construct a three-sector model with an aggregated private sector in which the only stocks visible were net financial assets for each sector and the visible transactions were the inter-sectoral flows at that level, supplemented by private expenditure (which is actually internal to the private sector at this level of aggregation). The reason for choosing such a highly aggregated model was that it was the simplest model that displayed the variables (the high-level stocks and flows) needed to address the thesis question concerning the stability of stock-flow ratios (particularly the private sector wealth-income norm) and the existence of the partial adjustment dynamic.

This approach is well suited to sectoral models like the SFC method, where the gradual and controlled 'opening up' of the black box can be effected through progressive disaggregation of the sectors of the model. The various ideas behind this approach have been in general use for some time, but putting them together in this way is an original contribution to SFC practice, particularly the use of an aggregated three sector model, and one which could serve as an example.

7.3 Next Steps

This study has used an aggregated three sector SFC model of the US economy. The main purpose was to investigate the action of the flow ratios and the stock-flow norms in the dynamics of the economy by empirical means; a secondary purpose was to explore the applicability of the data-first approach, using a cointegrating VECM as a model of the data in which to interpret rival theory models. The results of that effort were sufficiently positive to warrant taking the approach further. There are two potential directions for continuation, firstly to extend the analysis to other economies, and secondly to disaggregate the model.

Extension to other Economies: The US economy was chosen mainly because of the ready availability of data, the Flow of Funds accounts have been collected for the US economy since 1949. Very high quality macroeconomic data is available for EU economies through the Eurostat system but the time series are short, only going back to the mid-1990s. Longer history data for the UK is available through the ONS but without flow of funds accounts — Martin (2012) describes reconstruction of the UK flow of funds for his estimation of the New Cambridge equation.

Data considerations aside, the issue identified in section 5.7 concerning the non-convergence of the 'mixed' economies merits further investigation of the reasons for the special behaviour of these particular economies.

The US economy is special, being less constrained by its budget and current account deficits than others, which meant that some of the expected partial adjustment processes were not apparent. To see the effects of the balance of payments growth constraint would require modelling of a developing economy, but data would be a challenge. The SFC model of the CARICOM economies by Caldentey (2007) is an example of this.

Disaggregation of the Model: The natural successor to this model would be a disaggregated version capable of capturing richer economic dynamics than was possible with the three sector model. The private sector could be split into households, non-financial firms and the financial sector. The public sector could be split into the central bank and the treasury.

Disaggregating the private sector enables a greater set of transactions, in particular private consumption and investment, and non-financial assets — fixed capital and inventories in the firms sector, and housing wealth for the household sector. It can also capture the key prices in an economy — wage rates, the profit rate, the interest rate and several rates of return, the exchange rate and foreign interest rates.

In short, such a disaggregated model could contain sufficient detail to be capable of fully representing the macroeconomic behaviour of a realistic economy by building on the results obtained in this research.

Appendices

Appendix A

Glossary of Terms and Abbreviations

ARDL Auto Regressive Distributed Lag

CBO Congressional Budget Office

CEPG Cambridge Economic Policy Group

CEPR Cambridge Economic Policy Review

CFTR Combined Fiscal and Trade Ratio

DAE Department of Applied Economics, Cambridge University

DSGE Dynamic Stochastic General Equilibrium

EAP Economic Advisors to the President

FA Financial Assets

FoF Flow of Funds

FS Fiscal Stance

GFC Global Financial Crisis

IIP International Investment Position

IMA Integrated Macroeconomic Accounts of the United States

LCH Life Cycle Hypothesis model of consumption

NFA Net Financial Assets

NIPA National Income and Product Accounts

NLB Net Lending/Borrowing (from the sectoral national income accounts)

OLS Ordinary Least Squares regression

PDY Private Disposable Income

PIH Permanent Income Hypothesis model of consumption

RSS Residual Sum of Squares

SEM Structural Econometric Model

SFC Stock-Flow Consistent

TR Trade Ratio

VAR Vector Autoregression model

VECM Vector Error Correction model

Appendix B

The Expenditure Flow VECM

This appendix gives a listing of the coefficients and standard errors for the estimated equations of the six variable Expenditure Flow VECM of section 6.4.1 (p.297).

B.1 Coefficients and Standard Errors

Given the high number of lags, the coefficients have had to be split over four tables,

Table B.1.1: the flow variables, ΔPX, ΔG and ΔX for the first period, 1960$Q$2 to 1998$Q$1

Table B.1.2: the stock variables, ΔFA, ΔGD and ΔFR for the first period, 1960$Q$2 to 1998$Q$1

Table B.1.3: the flow variables, ΔPX, ΔG and ΔX for the second period, 1960$Q$2 to 2016$Q$4

Table B.1.4: the flow variables, ΔFA, ΔGD and ΔFR for the second period, 1960$Q$2 to 2016$Q$4

Coefficient	Equation for ΔPX Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔG Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔX Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	−0.25	0.11	−2.24	0.03	0.04	0.03	1.37	0.17	0.19	0.04	4.61	0
$ect2$	0.55	0.2	2.74	0.01	−0.08	0.06	−1.39	0.17	−0.36	0.07	−4.9	0
$ect3$	0.28	0.11	2.62	0.01	−0.01	0.03	−0.38	0.71	−0.16	0.04	−4.2	0
$constant$	−8.28	2.61	−3.17	0	1.3	0.76	1.71	0.09	4.39	0.96	4.58	0
$sd1$	0	0	−0.38	0.7	0	0	−1.16	0.25	0	0	0.82	0.41
$sd2$	0	0	−0.06	0.95	0	0	−0.24	0.81	0	0	0.28	0.78
$sd3$	0	0	1.36	0.18	0	0	−0.59	0.56	0	0	0.54	0.59
$px.dl1$	0.15	0.12	1.27	0.21	0.13	0.03	3.83	0	0.15	0.04	3.42	0
$g.dl1$	0.28	0.35	0.82	0.42	−0.31	0.1	−3.08	0	−0.14	0.13	−1.08	0.28
$x.dl1$	0.09	0.31	0.29	0.77	−0.07	0.09	−0.73	0.47	−0.41	0.11	−3.63	0
$fa.dl1$	0.13	0.05	2.68	0.01	0.01	0.01	0.45	0.66	−0.02	0.02	−1.02	0.31
$gd.dl1$	0.05	0.24	0.19	0.85	0.01	0.07	0.13	0.9	0.1	0.09	1.18	0.24
$fr.dl1$	0.01	0.08	0.17	0.86	0.03	0.02	1.19	0.24	0.01	0.03	0.39	0.7
$px.dl2$	0.08	0.12	0.69	0.49	0	0.04	−0.12	0.9	0.11	0.04	2.44	0.02
$g.dl2$	0.88	0.36	2.42	0.02	−0.34	0.11	−3.22	0	−0.05	0.13	−0.36	0.72
$x.dl2$	0.06	0.33	0.17	0.86	−0.05	0.1	−0.56	0.58	0	0.12	0	1
$fa.dl2$	0.03	0.05	0.58	0.57	0	0.01	0.05	0.96	−0.02	0.02	−1.16	0.25
$gd.dl2$	0.28	0.25	1.12	0.27	0.11	0.07	1.54	0.13	−0.02	0.09	−0.23	0.82
$fr.dl2$	0.08	0.08	0.98	0.33	−0.09	0.02	−4.25	0	−0.02	0.03	−0.58	0.57
$px.dl3$	−0.28	0.13	−2.19	0.03	0.02	0.04	0.65	0.52	0.05	0.05	0.98	0.33
$g.dl3$	−0.44	0.37	−1.17	0.24	−0.03	0.11	−0.29	0.77	0.18	0.14	1.3	0.2
$x.dl3$	0.62	0.31	1.99	0.05	0.05	0.09	0.57	0.57	0.07	0.11	0.62	0.54
$fa.dl3$	0.02	0.05	0.38	0.7	−0.01	0.01	−0.42	0.68	0.01	0.02	0.68	0.5
$gd.dl3$	−0.53	0.29	−1.81	0.07	−0.09	0.09	−1.01	0.31	−0.02	0.11	−0.18	0.85
$fr.dl3$	0.07	0.09	0.79	0.43	0.02	0.02	0.84	0.4	−0.02	0.03	−0.7	0.49
$px.dl4$	−0.08	0.13	−0.6	0.55	0.12	0.04	3.13	0	−0.02	0.05	−0.35	0.73
$g.dl4$	0.28	0.39	0.71	0.48	0.12	0.11	1.05	0.3	0	0.14	0.03	0.98
$x.dl4$	0.38	0.31	1.23	0.22	−0.14	0.09	−1.56	0.12	−0.24	0.11	−2.14	0.04
$fa.dl4$	0.01	0.05	0.12	0.9	0.03	0.01	1.99	0.05	0.01	0.02	0.71	0.48
$gd.dl4$	0.29	0.29	1.01	0.32	0.02	0.08	0.19	0.85	0.19	0.11	1.81	0.07
$fr.dl4$	0.18	0.09	2.03	0.05	0	0.03	0.17	0.86	0.04	0.03	1.32	0.19
$px.dl5$	−0.33	0.14	−2.45	0.02	0.1	0.04	2.42	0.02	0.1	0.05	2.03	0.05
$g.dl5$	0.31	0.38	0.82	0.41	0.11	0.11	1	0.32	−0.14	0.14	−0.99	0.33
$x.dl5$	0.58	0.3	1.9	0.06	0.03	0.09	0.39	0.7	−0.2	0.11	−1.82	0.07
$fa.dl5$	0.06	0.05	1.33	0.19	0	0.01	0.32	0.75	−0.01	0.02	−0.64	0.52
$gd.dl5$	0.04	0.26	0.15	0.88	−0.21	0.08	−2.7	0.01	−0.03	0.1	−0.33	0.74
$fr.dl5$	0.01	0.09	0.11	0.91	0.02	0.02	0.71	0.48	−0.01	0.03	−0.44	0.66
$px.dl6$	−0.13	0.14	−0.89	0.37	0.15	0.04	3.59	0	0.08	0.05	1.59	0.12
$g.dl6$	0.28	0.36	0.76	0.45	0.11	0.11	1.07	0.29	−0.26	0.13	−1.98	0.05
$x.dl6$	−0.34	0.32	−1.07	0.29	−0.12	0.09	−1.32	0.19	0.03	0.12	0.24	0.81
$fa.dl6$	−0.1	0.05	−2.15	0.03	0.01	0.01	0.55	0.58	−0.01	0.02	−0.8	0.42
$gd.dl6$	−0.22	0.26	−0.84	0.4	0	0.08	0.01	0.99	0.09	0.1	0.95	0.34
$fr.dl6$	0.07	0.09	0.78	0.44	−0.03	0.03	−1.15	0.25	−0.11	0.03	−3.29	0
$px.dl7$	−0.17	0.14	−1.16	0.25	0.05	0.04	1.23	0.22	0.01	0.05	0.15	0.88
$g.dl7$	−0.73	0.34	−2.12	0.04	0.22	0.1	2.24	0.03	−0.54	0.13	−4.29	0
$x.dl7$	−0.13	0.36	−0.36	0.72	0.28	0.1	2.65	0.01	−0.14	0.13	−1.04	0.3
$fa.dl7$	−0.04	0.05	−0.79	0.43	0.01	0.01	0.6	0.55	−0.02	0.02	−1.03	0.31
$gd.dl7$	0.11	0.24	0.44	0.66	−0.08	0.07	−1.17	0.24	0.06	0.09	0.65	0.52
$fr.dl7$	0.1	0.09	1.16	0.25	−0.06	0.03	−2.29	0.02	−0.07	0.03	−2.09	0.04
$px.dl8$	−0.35	0.15	−2.4	0.02	0.04	0.04	1	0.32	0.1	0.05	1.81	0.07
$g.dl8$	−0.96	0.36	−2.65	0.01	−0.18	0.11	−1.7	0.09	−0.46	0.13	−3.47	0
$x.dl8$	0.29	0.36	0.79	0.43	0.23	0.11	2.18	0.03	−0.5	0.13	−3.72	0
$fa.dl8$	−0.08	0.05	−1.77	0.08	0	0.01	0.33	0.74	−0.01	0.02	−0.4	0.69
$gd.dl8$	−0.06	0.24	−0.27	0.79	−0.07	0.07	−0.99	0.33	−0.02	0.09	−0.22	0.82
$fr.dl8$	0.15	0.09	1.71	0.09	−0.06	0.03	−2.46	0.02	−0.08	0.03	−2.5	0.01
$px.dl9$	−0.17	0.15	−1.11	0.27	0.11	0.04	2.55	0.01	0.19	0.05	3.4	0
$g.dl9$	0.32	0.4	0.8	0.42	0.16	0.12	1.34	0.19	−0.09	0.15	−0.62	0.54
$x.dl9$	0.53	0.37	1.46	0.15	−0.41	0.11	−3.82	0	−0.27	0.13	−2.04	0.04
$fa.dl9$	0.03	0.05	0.55	0.58	0.03	0.01	1.86	0.07	0	0.02	−0.27	0.78
$gd.dl9$	0.02	0.23	0.07	0.94	0.16	0.07	2.41	0.02	−0.06	0.08	−0.74	0.46
$fr.dl9$	0.01	0.09	0.12	0.9	−0.09	0.03	−3.52	0	−0.06	0.03	−1.9	0.06

Table B.1.1: First Time Period: 1960$Q2$ to 1998$Q1$: Flow Variables

Coefficient	Equation for ΔFA				Equation for ΔGD				Equation for ΔFR			
	Est'mt	Std Error	t-value	Pr (>|t|)	Est'mt	Std Error	t-value	Pr (>|t|)	Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	0.09	0.33	0.28	0.78	0.06	0.06	0.92	0.36	0.26	0.17	1.51	0.14
$ect2$	−0.07	0.61	−0.12	0.9	−0.01	0.11	−0.05	0.96	−0.41	0.32	−1.29	0.2
$ect3$	−0.06	0.32	−0.2	0.85	0.13	0.06	2.12	0.04	−0.06	0.17	−0.33	0.74
$constant$	−2.5	7.9	−0.32	0.75	−0.77	1.47	−0.53	0.6	4.34	4.13	1.05	0.3
$sd1$	0	0	−0.25	0.8	0	0	−1.08	0.28	0	0	−1.31	0.19
$sd2$	0	0	−1.23	0.22	0	0	−1.56	0.12	0	0	0.15	0.88
$sd3$	0	0	0.29	0.77	0	0	−2.69	0.01	0	0	−2.06	0.04
$px.dl1$	−0.61	0.36	−1.7	0.09	0.05	0.07	0.73	0.47	0.09	0.19	0.5	0.62
$g.dl1$	−1.63	1.04	−1.56	0.12	0.25	0.19	1.3	0.2	−0.16	0.55	−0.29	0.77
$x.dl1$	1.25	0.94	1.33	0.19	−0.59	0.18	−3.36	0	0.17	0.49	0.34	0.74
$fa.dl1$	0.02	0.14	0.16	0.88	−0.07	0.03	−2.69	0.01	−0.06	0.07	−0.79	0.43
$gd.dl1$	−0.66	0.73	−0.91	0.37	0.32	0.14	2.37	0.02	0.79	0.38	2.06	0.04
$fr.dl1$	−0.24	0.24	−0.98	0.33	0.01	0.04	0.24	0.81	0.08	0.13	0.6	0.55
$px.dl2$	0.32	0.37	0.86	0.39	−0.11	0.07	−1.65	0.1	−0.21	0.19	−1.12	0.27
$g.dl2$	0.55	1.1	0.5	0.62	−0.05	0.21	−0.25	0.8	−0.97	0.58	−1.68	0.1
$x.dl2$	0.1	1	0.1	0.92	0.07	0.19	0.36	0.72	0.16	0.52	0.3	0.77
$fa.dl2$	−0.01	0.15	−0.06	0.95	−0.02	0.03	−0.77	0.44	−0.04	0.08	−0.52	0.6
$gd.dl2$	2.32	0.75	3.09	0	−0.6	0.14	−4.27	0	−0.55	0.39	−1.41	0.16
$fr.dl2$	0.23	0.23	1	0.32	−0.12	0.04	−2.88	0.01	0.05	0.12	0.45	0.65
$px.dl3$	−0.54	0.39	−1.4	0.17	0.08	0.07	1.16	0.25	0.07	0.2	0.36	0.72
$g.dl3$	−1.44	1.13	−1.27	0.21	0.37	0.21	1.76	0.08	−0.72	0.59	−1.21	0.23
$x.dl3$	−0.34	0.94	−0.36	0.72	−0.01	0.18	−0.04	0.97	−0.39	0.49	−0.8	0.43
$fa.dl3$	−0.24	0.15	−1.63	0.11	−0.01	0.03	−0.22	0.82	0.1	0.08	1.25	0.21
$gd.dl3$	−0.73	0.88	−0.82	0.41	0.52	0.16	3.14	0	0.42	0.46	0.91	0.37
$fr.dl3$	0.13	0.26	0.5	0.62	−0.09	0.05	−1.88	0.06	0.06	0.13	0.42	0.68
$px.dl4$	−0.08	0.39	−0.21	0.83	−0.12	0.07	−1.7	0.09	0.01	0.2	0.05	0.96
$g.dl4$	−0.97	1.18	−0.82	0.41	0.01	0.22	0.03	0.98	−1.41	0.62	−2.28	0.03
$x.dl4$	−0.23	0.92	−0.25	0.8	0.07	0.17	0.42	0.68	0.13	0.48	0.27	0.79
$fa.dl4$	−0.19	0.14	−1.32	0.19	−0.03	0.03	−1.24	0.22	0.01	0.07	0.12	0.9
$gd.dl4$	0.89	0.87	1.03	0.31	−0.02	0.16	−0.13	0.9	0.39	0.45	0.86	0.39
$fr.dl4$	0.32	0.26	1.22	0.22	0.01	0.05	0.24	0.81	−0.14	0.14	−1.02	0.31
$px.dl5$	0.14	0.41	0.34	0.74	−0.1	0.08	−1.36	0.18	0.38	0.21	1.8	0.08
$g.dl5$	−0.17	1.15	−0.15	0.88	−0.48	0.21	−2.25	0.03	−0.81	0.6	−1.35	0.18
$x.dl5$	1.35	0.92	1.47	0.15	0.29	0.17	1.71	0.09	−0.66	0.48	−1.38	0.17
$fa.dl5$	0.12	0.14	0.82	0.41	−0.06	0.03	−2.37	0.02	−0.15	0.07	−2.03	0.05
$gd.dl5$	1.26	0.8	1.58	0.12	0.01	0.15	0.1	0.92	−0.12	0.42	−0.29	0.77
$fr.dl5$	0.12	0.26	0.47	0.64	0	0.05	0.07	0.94	−0.12	0.13	−0.9	0.37
$px.dl6$	0.1	0.43	0.24	0.81	−0.14	0.08	−1.73	0.09	0.08	0.22	0.36	0.72
$g.dl6$	0.86	1.1	0.78	0.44	−0.04	0.2	−0.19	0.85	−0.9	0.57	−1.57	0.12
$x.dl6$	−0.85	0.97	−0.87	0.38	0.68	0.18	3.76	0	0.49	0.51	0.96	0.34
$fa.dl6$	−0.33	0.14	−2.32	0.02	0	0.03	0.17	0.87	0.11	0.07	1.53	0.13
$gd.dl6$	−1.04	0.8	−1.3	0.2	0.25	0.15	1.67	0.1	−0.35	0.42	−0.83	0.41
$fr.dl6$	0.23	0.27	0.87	0.39	−0.09	0.05	−1.8	0.08	−0.07	0.14	−0.51	0.61
$px.dl7$	−0.27	0.43	−0.63	0.53	−0.16	0.08	−2.04	0.05	0.19	0.23	0.83	0.41
$g.dl7$	1.23	1.04	1.19	0.24	−0.55	0.19	−2.83	0.01	−0.15	0.54	−0.28	0.78
$x.dl7$	−0.7	1.08	−0.65	0.52	0.35	0.2	1.71	0.09	−0.68	0.57	−1.2	0.23
$fa.dl7$	−0.09	0.14	−0.6	0.55	−0.05	0.03	−1.76	0.08	−0.03	0.07	−0.46	0.65
$gd.dl7$	−0.35	0.72	−0.49	0.63	0.16	0.13	1.2	0.23	0.32	0.38	0.85	0.4
$fr.dl7$	0.04	0.27	0.13	0.89	−0.04	0.05	−0.71	0.48	0.15	0.14	1.05	0.3
$px.dl8$	0.55	0.45	1.22	0.22	−0.12	0.08	−1.42	0.16	0.03	0.23	0.13	0.89
$g.dl8$	−0.59	1.1	−0.54	0.59	0.29	0.21	1.42	0.16	−1.34	0.58	−2.33	0.02
$x.dl8$	0.06	1.1	0.06	0.96	−0.14	0.21	−0.68	0.5	0.24	0.58	0.42	0.67
$fa.dl8$	−0.06	0.14	−0.42	0.68	−0.02	0.03	−0.91	0.37	0.04	0.08	0.49	0.62
$gd.dl8$	0.17	0.71	0.24	0.81	0.33	0.13	2.49	0.01	−0.63	0.37	−1.7	0.09
$fr.dl8$	0.75	0.27	2.78	0.01	−0.06	0.05	−1.29	0.2	−0.09	0.14	−0.61	0.54
$px.dl9$	0.25	0.45	0.55	0.59	0.01	0.08	0.08	0.94	0.59	0.24	2.5	0.01
$g.dl9$	−0.79	1.22	−0.65	0.52	−0.13	0.23	−0.59	0.56	−0.33	0.64	−0.52	0.6
$x.dl9$	0.44	1.11	0.4	0.69	0.1	0.21	0.48	0.63	−0.22	0.58	−0.39	0.7
$fa.dl9$	−0.21	0.14	−1.47	0.14	0	0.03	−0.04	0.97	−0.09	0.07	−1.15	0.25
$gd.dl9$	−1.23	0.69	−1.79	0.08	0.08	0.13	0.66	0.51	−0.16	0.36	−0.43	0.67
$fr.dl9$	−0.29	0.27	−1.08	0.28	0.12	0.05	2.48	0.02	0.05	0.14	0.34	0.74

Table B.1.2: First Time Period: 1960$Q2$ to 1998$Q1$: Stock Variables

Coefficient	Equation for ΔPX Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔG Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔX Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	0.02	0.01	1.84	0.07	0.01	0.01	1.09	0.28	0.03	0.01	2.01	0.05
$ect2$	0.03	0.08	0.34	0.74	0.08	0.04	2.09	0.04	0.19	0.08	2.4	0.02
$ect3$	0.01	0.02	0.61	0.54	−0.02	0.01	−1.77	0.08	−0.04	0.02	−2.06	0.04
$constant$	−0.03	0.44	−0.07	0.95	−0.44	0.22	−2	0.05	−1.09	0.46	−2.39	0.02
$sd1$	0	0	0.67	0.51	0	0	0.66	0.51	0	0	1.63	0.11
$sd2$	0	0	−0.91	0.36	0	0	1.47	0.14	0	0	−0.29	0.78
$sd3$	0	0	0.46	0.65	0	0	1.42	0.16	0	0	1.15	0.25
$px.dl1$	0.21	0.09	2.25	0.03	0.06	0.05	1.3	0.2	0.02	0.1	0.24	0.81
$g.dl1$	−0.22	0.16	−1.35	0.18	−0.41	0.08	−5.09	0	0.06	0.17	0.34	0.74
$x.dl1$	0.15	0.1	1.42	0.16	0.08	0.05	1.61	0.11	0.51	0.11	4.81	0
$fa.dl1$	0.06	0.02	2.91	0	−0.01	0.01	−0.86	0.39	0.05	0.02	2.4	0.02
$gd.dl1$	−0.01	0.05	−0.19	0.85	−0.01	0.03	−0.41	0.68	−0.03	0.06	−0.61	0.55
$fr.dl1$	−0.02	0.01	−1.89	0.06	0.01	0.01	1.34	0.18	−0.03	0.01	−2.02	0.04
$px.dl2$	−0.08	0.1	−0.83	0.41	−0.04	0.05	−0.81	0.42	−0.21	0.1	−2.08	0.04
$g.dl2$	−0.14	0.18	−0.79	0.43	−0.13	0.09	−1.53	0.13	−0.08	0.18	−0.44	0.66
$x.dl2$	−0.24	0.11	−2.14	0.03	−0.12	0.06	−2.14	0.03	−0.46	0.12	−3.9	0
$fa.dl2$	0.07	0.02	3.4	0	−0.01	0.01	−1.09	0.28	0.02	0.02	0.68	0.5
$gd.dl2$	0.02	0.05	0.38	0.7	−0.04	0.03	−1.51	0.13	−0.13	0.05	−2.5	0.01
$fr.dl2$	0.02	0.01	1.38	0.17	0	0.01	−0.39	0.7	0.03	0.01	2.47	0.01
$px.dl3$	−0.08	0.09	−0.93	0.36	0	0.04	−0.04	0.96	−0.12	0.09	−1.25	0.21
$g.dl3$	−0.61	0.17	−3.48	0	−0.03	0.09	−0.33	0.74	−0.16	0.18	−0.89	0.38
$x.dl3$	−0.27	0.12	−2.31	0.02	0.02	0.06	0.28	0.78	−0.15	0.12	−1.25	0.21
$fa.dl3$	0.02	0.02	0.77	0.44	−0.01	0.01	−0.9	0.37	0	0.02	0.03	0.98
$gd.dl3$	−0.13	0.05	−2.34	0.02	−0.03	0.03	−1.05	0.29	−0.08	0.06	−1.52	0.13
$fr.dl3$	0.01	0.01	0.81	0.42	0	0.01	0.43	0.67	0	0.01	0.21	0.84
$px.dl4$	0	0.09	−0.05	0.96	0.02	0.05	0.52	0.6	0.12	0.1	1.23	0.22
$g.dl4$	−0.6	0.18	−3.4	0	0.23	0.09	2.66	0.01	−0.04	0.18	−0.2	0.84
$x.dl4$	−0.16	0.11	−1.42	0.16	−0.03	0.05	−0.54	0.59	−0.25	0.12	−2.21	0.03
$fa.dl4$	0	0.02	0.1	0.92	−0.01	0.01	−1.02	0.31	−0.03	0.02	−1.27	0.21
$gd.dl4$	−0.05	0.05	−0.92	0.36	−0.05	0.03	−2.05	0.04	−0.15	0.05	−2.73	0.01
$fr.dl4$	0.02	0.01	1.93	0.06	0	0.01	−0.46	0.64	0.02	0.01	1.89	0.06
$px.dl5$	−0.04	0.09	−0.41	0.68	0.04	0.04	0.94	0.35	0.04	0.09	0.39	0.7
$g.dl5$	−0.37	0.18	−1.98	0.05	0.31	0.09	3.44	0	−0.01	0.19	−0.04	0.96
$x.dl5$	−0.07	0.11	−0.64	0.53	−0.17	0.06	−3.14	0	−0.18	0.12	−1.52	0.13
$fa.dl5$	0.05	0.02	2.11	0.04	0	0.01	−0.43	0.67	−0.02	0.02	−0.8	0.43
$gd.dl5$	0.12	0.05	2.4	0.02	−0.02	0.02	−1	0.32	0	0.05	0.09	0.93
$fr.dl5$	−0.01	0.01	−1.09	0.28	0.02	0.01	2.55	0.01	−0.02	0.01	−1.15	0.25
$px.dl6$	0.1	0.09	1.19	0.24	0.09	0.04	2.07	0.04	−0.05	0.09	−0.53	0.6
$g.dl6$	−0.66	0.2	−3.31	0	0.14	0.1	1.39	0.17	−0.48	0.2	−2.35	0.02
$x.dl6$	−0.26	0.12	−2.15	0.03	−0.15	0.06	−2.46	0.01	0.01	0.13	0.11	0.91
$fa.dl6$	−0.03	0.02	−1.31	0.19	−0.02	0.01	−1.46	0.15	−0.03	0.02	−1.27	0.21
$gd.dl6$	0.01	0.05	0.26	0.8	−0.04	0.02	−1.58	0.12	−0.01	0.05	−0.19	0.85
$fr.dl6$	0.04	0.01	2.75	0.01	0	0.01	0.71	0.48	0.03	0.01	2.32	0.02
$px.dl7$	0.09	0.09	0.99	0.32	0.03	0.04	0.6	0.55	−0.01	0.09	−0.07	0.95
$g.dl7$	−0.67	0.21	−3.17	0	0.05	0.1	0.48	0.63	−0.5	0.22	−2.28	0.02
$x.dl7$	0.04	0.12	0.37	0.71	0.05	0.06	0.89	0.38	0.04	0.12	0.33	0.74
$fa.dl7$	0	0.02	0.16	0.87	−0.01	0.01	−0.57	0.57	0	0.03	−0.01	0.99
$gd.dl7$	0.02	0.05	0.49	0.62	−0.01	0.02	−0.43	0.67	0.01	0.05	0.16	0.88
$fr.dl7$	0	0.01	−0.24	0.81	0.01	0.01	1.53	0.13	−0.01	0.01	−0.66	0.51
$px.dl8$	−0.17	0.09	−1.93	0.06	0.03	0.04	0.65	0.52	0.07	0.09	0.79	0.43
$g.dl8$	−0.22	0.21	−1.05	0.3	−0.03	0.1	−0.26	0.8	0.49	0.22	2.26	0.03
$x.dl8$	−0.21	0.12	−1.74	0.08	−0.06	0.06	−1.04	0.3	−0.42	0.13	−3.3	0
$fa.dl8$	−0.02	0.03	−0.68	0.5	−0.02	0.01	−1.79	0.08	−0.07	0.03	−2.55	0.01
$gd.dl8$	−0.05	0.05	−1.06	0.29	−0.02	0.02	−0.64	0.53	0	0.05	−0.06	0.95
$fr.dl8$	0.04	0.01	3.33	0	0.01	0.01	1.15	0.25	0.03	0.01	1.84	0.07
$px.dl9$	0.11	0.09	1.22	0.22	0.02	0.04	0.52	0.6	−0.12	0.09	−1.25	0.21
$g.dl9$	0.09	0.21	0.43	0.67	0.02	0.1	0.24	0.81	0.26	0.21	1.22	0.23
$x.dl9$	−0.14	0.13	−1.08	0.28	0.17	0.06	2.6	0.01	0.13	0.14	0.93	0.35
$fa.dl9$	−0.03	0.03	−1	0.32	0.01	0.01	0.46	0.65	−0.05	0.03	−1.86	0.06
$gd.dl9$	−0.07	0.05	−1.46	0.15	−0.02	0.02	−0.73	0.46	−0.07	0.05	−1.47	0.15
$fr.dl9$	−0.01	0.01	−0.62	0.54	−0.02	0.01	−3.38	0	−0.02	0.01	−1.7	0.09

Table B.1.3: Second Time Period: 1960$Q2$ to 2016$Q4$: Flow Variables

Coefficient	Equation for ΔFA Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔGD Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔFR Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	0.14	0.06	2.23	0.03	0.03	0.02	1.41	0.16	0.58	0.11	5.34	0
$ect2$	0.87	0.36	2.41	0.02	0.24	0.14	1.77	0.08	−1.05	0.62	−1.71	0.09
$ect3$	−0.22	0.09	−2.46	0.02	−0.05	0.03	−1.37	0.17	0.28	0.15	1.85	0.07
$constant$	−5.44	2.08	−2.61	0.01	−1.33	0.79	−1.68	0.1	4.03	3.56	1.13	0.26
$sd1$	0	0	−0.53	0.6	0	0	−0.22	0.83	0	0.01	0.07	0.94
$sd2$	−0.01	0	−1.36	0.18	0	0	−0.7	0.49	0	0.01	0.03	0.97
$sd3$	−0.01	0	−1.83	0.07	0	0	−0.62	0.54	0	0.01	0.39	0.7
$px.dl1$	0.75	0.43	1.73	0.09	−0.51	0.16	−3.08	0	−0.54	0.74	−0.73	0.46
$g.dl1$	0.6	0.77	0.78	0.44	0.29	0.29	1.01	0.31	1.55	1.31	1.18	0.24
$x.dl1$	1.08	0.48	2.23	0.03	−0.97	0.18	−5.29	0	4.48	0.82	5.44	0
$fa.dl1$	0.13	0.1	1.23	0.22	−0.04	0.04	−1.06	0.29	0.4	0.18	2.25	0.03
$gd.dl1$	0.4	0.25	1.58	0.12	−0.19	0.1	−1.97	0.05	0.06	0.43	0.13	0.9
$fr.dl1$	−0.05	0.06	−0.86	0.39	0.04	0.02	1.89	0.06	−0.35	0.1	−3.62	0
$px.dl2$	−0.03	0.45	−0.06	0.95	0.11	0.17	0.63	0.53	−1.99	0.77	−2.59	0.01
$g.dl2$	0.1	0.82	0.12	0.91	0.04	0.31	0.12	0.91	−2.01	1.41	−1.43	0.16
$x.dl2$	−0.68	0.54	−1.28	0.2	0.27	0.2	1.31	0.19	−1.47	0.91	−1.61	0.11
$fa.dl2$	−0.09	0.1	−0.88	0.38	0.02	0.04	0.51	0.61	0.33	0.18	1.91	0.06
$gd.dl2$	−0.51	0.24	−2.14	0.03	0.19	0.09	2.12	0.04	−0.41	0.41	−0.99	0.32
$fr.dl2$	−0.04	0.06	−0.64	0.52	−0.03	0.02	−1.51	0.13	−0.38	0.1	−3.87	0
$px.dl3$	−0.42	0.43	−0.98	0.33	0.27	0.16	1.64	0.1	−1	0.73	−1.36	0.18
$g.dl3$	−0.28	0.82	−0.35	0.73	0.07	0.31	0.24	0.81	−0.96	1.4	−0.69	0.49
$x.dl3$	−1.23	0.55	−2.25	0.03	0.35	0.21	1.69	0.09	−0.22	0.94	−0.24	0.81
$fa.dl3$	−0.01	0.11	−0.11	0.91	−0.02	0.04	−0.61	0.54	0.36	0.18	1.95	0.05
$gd.dl3$	−0.54	0.25	−2.15	0.03	0.11	0.1	1.16	0.25	−0.7	0.43	−1.62	0.11
$fr.dl3$	0.11	0.06	1.79	0.08	−0.01	0.02	−0.28	0.78	−0.1	0.11	−0.94	0.35
$px.dl4$	0.54	0.43	1.24	0.22	−0.18	0.17	−1.11	0.27	0.61	0.74	0.82	0.41
$g.dl4$	−1.14	0.83	−1.37	0.17	−0.11	0.32	−0.34	0.74	0.4	1.42	0.28	0.78
$x.dl4$	−1.07	0.52	−2.05	0.04	0.18	0.2	0.9	0.37	−2.18	0.89	−2.44	0.02
$fa.dl4$	−0.19	0.11	−1.76	0.08	0.02	0.04	0.46	0.65	0.08	0.18	0.42	0.67
$gd.dl4$	−0.27	0.24	−1.1	0.27	0.01	0.09	0.14	0.89	−0.68	0.41	−1.64	0.1
$fr.dl4$	−0.05	0.06	−0.85	0.4	0.02	0.02	0.88	0.38	−0.28	0.1	−2.78	0.01
$px.dl5$	0.42	0.43	0.98	0.33	−0.1	0.16	−0.59	0.56	0.05	0.73	0.07	0.94
$g.dl5$	0.82	0.87	0.95	0.34	−0.18	0.33	−0.55	0.58	0.24	1.48	0.16	0.87
$x.dl5$	0.51	0.53	0.97	0.33	−0.35	0.2	−1.76	0.08	1.06	0.9	1.17	0.24
$fa.dl5$	−0.05	0.1	−0.45	0.65	−0.07	0.04	−1.88	0.06	0.08	0.17	0.47	0.64
$gd.dl5$	0.08	0.23	0.34	0.73	−0.14	0.09	−1.63	0.11	0.55	0.4	1.38	0.17
$fr.dl5$	0.01	0.06	0.22	0.83	0.04	0.02	1.62	0.11	−0.17	0.11	−1.65	0.1
$px.dl6$	0.34	0.4	0.84	0.4	0.04	0.15	0.24	0.81	−0.49	0.69	−0.7	0.48
$g.dl6$	−0.76	0.93	−0.82	0.41	0.49	0.35	1.39	0.17	−3.53	1.59	−2.22	0.03
$x.dl6$	−1.18	0.57	−2.07	0.04	0.14	0.22	0.66	0.51	−0.21	0.98	−0.22	0.83
$fa.dl6$	−0.16	0.1	−1.58	0.12	−0.16	0.04	−4.05	0	0.11	0.18	0.61	0.55
$gd.dl6$	−0.14	0.23	−0.63	0.53	−0.16	0.09	−1.82	0.07	0.4	0.39	1.03	0.31
$fr.dl6$	−0.06	0.06	−0.94	0.35	−0.04	0.02	−1.82	0.07	0.26	0.11	2.39	0.02
$px.dl7$	0.08	0.42	0.18	0.86	−0.09	0.16	−0.55	0.58	1.06	0.71	1.49	0.14
$g.dl7$	0.41	0.99	0.42	0.68	−0.48	0.38	−1.27	0.21	−2.26	1.69	−1.34	0.18
$x.dl7$	1.04	0.57	1.84	0.07	−0.06	0.21	−0.27	0.79	−0.6	0.97	−0.62	0.54
$fa.dl7$	−0.03	0.11	−0.29	0.77	−0.15	0.04	−3.37	0	0.21	0.2	1.06	0.29
$gd.dl7$	0.04	0.23	0.19	0.85	0.03	0.09	0.31	0.76	0.74	0.4	1.84	0.07
$fr.dl7$	0.06	0.06	0.96	0.34	0	0.02	−0.05	0.96	0.17	0.11	1.53	0.13
$px.dl8$	0.51	0.41	1.23	0.22	−0.19	0.16	−1.22	0.23	−0.72	0.71	−1.02	0.31
$g.dl8$	0.53	0.98	0.54	0.59	−0.63	0.37	−1.7	0.09	−2.49	1.68	−1.48	0.14
$x.dl8$	−2.13	0.57	−3.73	0	0.92	0.22	4.21	0	−0.3	0.98	−0.31	0.76
$fa.dl8$	0	0.12	0.03	0.98	−0.03	0.04	−0.69	0.49	0.21	0.2	1.06	0.29
$gd.dl8$	0.07	0.23	0.33	0.74	0.08	0.09	0.99	0.32	0.33	0.39	0.86	0.39
$fr.dl8$	−0.05	0.06	−0.86	0.39	−0.05	0.02	−2.13	0.03	−0.15	0.11	−1.46	0.15
$px.dl9$	0.43	0.43	1	0.32	0.19	0.16	1.14	0.26	−1.03	0.73	−1.41	0.16
$g.dl9$	0.33	0.96	0.34	0.73	0.79	0.37	2.15	0.03	−2.44	1.65	−1.48	0.14
$x.dl9$	−0.33	0.62	−0.53	0.59	−0.35	0.23	−1.51	0.13	2.67	1.05	2.54	0.01
$fa.dl9$	−0.36	0.12	−3	0	−0.01	0.05	−0.13	0.89	0.04	0.21	0.22	0.83
$gd.dl9$	−0.37	0.22	−1.64	0.1	−0.19	0.08	−2.26	0.03	0.33	0.38	0.85	0.39
$fr.dl9$	−0.03	0.06	−0.51	0.61	0.01	0.02	0.27	0.78	−0.07	0.1	−0.65	0.52

Table B.1.4: Second Time Period: 1960$Q2$ to 2016$Q4$: Stock Variables

Appendix C

Coefficients and Standard Errors for the Sectoral Models

This appendix gives a listing of the coefficients and standard errors for the estimated equations of the three variable sectoral VECM models of section 6.5 (p.312).

C.1 Coefficients and Standard Errors for the Private Sector VAR

First Time Period: $1960Q2$ **to** $1997Q2$

Coefficient	Equation for ΔPX				Equation for ΔYD				Equation for ΔFA			
	Est'mt	Std Error	t-value	Pr (>|t|)	Est'mt	Std Error	t-value	Pr (>|t|)	Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	-0.04	0.02	-1.59	0.12	0.02	0.02	1.21	0.23	0.37	0.1	3.82	0
$constant$	3.89	3.93	0.99	0.32	7.73	3.05	2.54	0.01	0.14	15.77	0.01	0.99
$sd1$	-2.2	6.2	-0.36	0.72	-3.28	4.81	-0.68	0.5	-48.42	24.9	-1.94	0.05
$sd2$	-2.69	6.28	-0.43	0.67	-2.33	4.87	-0.48	0.63	-66.97	25.23	-2.65	0.01
$sd3$	-3.94	6.14	-0.64	0.52	-2.77	4.76	-0.58	0.56	-74.51	24.66	-3.02	0
$px.dl1$	0.08	0.11	0.72	0.47	-0.12	0.08	-1.42	0.16	-0.61	0.43	-1.41	0.16
$yd.dl1$	0.49	0.13	3.74	0	0.2	0.1	2.02	0.05	0.53	0.52	1.01	0.32
$fa.dl1$	0.08	0.02	3.73	0	0.02	0.02	1.37	0.17	0.13	0.09	1.46	0.15

Second Time Period: $1960Q2$ **to** $2016Q4$

Coefficient	Equation for ΔPX Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔYD Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔFA Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	0	0	1.6	0.11	0.01	0	7.36	0	0.03	0.01	3.1	0
$constant$	6.04	6.67	0.91	0.37	7.39	7.9	0.93	0.35	−114.68	67.28	−1.7	0.09
$sd1$	8.06	10.73	0.75	0.45	6.62	12.72	0.52	0.6	−90.64	108.28	−0.84	0.4
$sd2$	−5.04	10.51	−0.48	0.63	−0.73	12.45	−0.06	0.95	−291.04	106.03	−2.74	0.01
$sd3$	−1.21	10.35	−0.12	0.91	−17.19	12.26	−1.4	0.16	−320.79	104.43	−3.07	0
$px.dl1$	0.42	0.06	6.67	0	0.03	0.08	0.43	0.67	3.41	0.64	5.33	0
$yd.dl1$	0.2	0.06	3.21	0	−0.02	0.07	−0.28	0.78	−0.71	0.62	−1.14	0.26
$fa.dl1$	0.02	0.01	3.35	0	−0.01	0.01	−1.49	0.14	0.05	0.07	0.75	0.45

C.2 Coefficients and Standard Errors for the Public Sector VAR

Time Period: $1960Q2$ **to** $1993Q4$

Coefficient	Equation for ΔG Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔY Est'mt	Std Error	t-value	Pr (>|t|)	Equation for ΔGD Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	−0.12	0.02	−5	0	−0.26	0.08	−3.14	0	−0.05	0.06	−0.79	0.43
$constant$	3.02	1.2	2.53	0.01	13.36	4.22	3.16	0	−0.82	2.89	−0.28	0.78
$sd1$	−0.15	1.81	−0.08	0.93	1.24	6.38	0.2	0.85	−14.16	4.37	−3.24	0
$sd2$	0.92	1.91	0.48	0.63	3.8	6.75	0.56	0.57	−16.3	4.62	−3.52	0
$sd3$	0.28	1.79	0.16	0.87	5.81	6.32	0.92	0.36	−13.14	4.33	−3.03	0
$g.dl1$	−0.46	0.1	−4.81	0	−0.67	0.34	−2.01	0.05	0.35	0.23	1.51	0.13
$y.dl1$	0	0.03	0.03	0.97	0.32	0.09	3.4	0	0.07	0.06	1.13	0.26
$gd.dl1$	−0.04	0.04	−1.12	0.26	−0.09	0.13	−0.69	0.49	0.41	0.09	4.45	0

C.3 Coefficients and Standard Errors for the Foreign Sector VAR

Time Period: $1960Q2$ **to** $1983Q1$

	Equation for ΔX				Equation for ΔY				Equation for ΔFR			
Coefficient	Est'mt	Std Error	t-value	Pr (>|t|)	Est'mt	Std Error	t-value	Pr (>|t|)	Est'mt	Std Error	t-value	Pr (>|t|)
$ect1$	−0.51	0.17	−3.07	0	−0.86	0.56	−1.53	0.13	1.21	0.19	6.27	0
$constant$	−26.03	8.05	−3.23	0	−36.3	27.38	−1.33	0.19	57.4	9.4	6.1	0
$sd1$	2.39	2.02	1.18	0.24	−5.85	6.87	−0.85	0.4	−5.5	2.36	−2.33	0.02
$sd2$	−0.28	1.73	−0.16	0.87	−0.24	5.9	−0.04	0.97	−2.39	2.03	−1.18	0.24
$sd3$	1.15	1.94	0.59	0.56	−3.57	6.61	−0.54	0.59	−5.83	2.27	−2.57	0.01
$x.dl1$	−0.19	0.14	−1.37	0.17	−0.5	0.47	−1.06	0.29	0.15	0.16	0.89	0.38
$y.dl1$	0.13	0.04	3.15	0	0.23	0.14	1.61	0.11	−0.05	0.05	−0.92	0.36
$fr.dl1$	0	0.12	0	1	−0.27	0.41	−0.65	0.52	−0.62	0.14	−4.36	0
$fr.dl1$	0.14	0.13	1.04	0.3	−0.78	0.44	−1.77	0.08	0.52	0.15	3.43	0
$y.dl2$	0	0.04	−0.05	0.96	0.23	0.13	1.77	0.08	−0.21	0.04	−4.68	0
$fr.dl2$	0.12	0.12	0.97	0.34	−0.16	0.41	−0.4	0.69	−0.33	0.14	−2.29	0.03
$x.dl3$	0.16	0.15	1.06	0.29	0.04	0.5	0.08	0.94	0.15	0.17	0.86	0.39
$y.dl3$	0.07	0.04	1.53	0.13	0.34	0.15	2.3	0.03	−0.11	0.05	−2.1	0.04
$fr.dl3$	−0.07	0.1	−0.71	0.48	0.01	0.32	0.03	0.98	−0.51	0.11	−4.55	0
$x.dl4$	−0.22	0.14	−1.57	0.12	1.63	0.48	3.38	0	0.86	0.17	5.21	0
$y.dl4$	0.09	0.04	2.16	0.04	−0.06	0.15	−0.42	0.68	−0.03	0.05	−0.52	0.61
$fr.dl4$	0.24	0.11	2.26	0.03	−0.06	0.37	−0.16	0.88	−0.22	0.13	−1.72	0.09
$x.dl5$	−0.17	0.19	−0.93	0.36	0.91	0.63	1.43	0.16	0.56	0.22	2.56	0.01
$y.dl5$	0.03	0.04	0.82	0.41	−0.28	0.14	−2.1	0.04	0.06	0.05	1.31	0.2
$fr.dl5$	0.18	0.11	1.61	0.11	0.75	0.38	1.96	0.05	−0.14	0.13	−1.04	0.3

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